U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY—Bulletin No. 81.

A. D. MELVIN, D. V. S., Chief of Bureau.

THE MILK SUPPLY

OF

BOSTON, NEW YORK, AND PHILADELPHIA.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., December 2, 1905.

Sir: I have the honor to transmit the accompanying report on "The Milk Supply of Boston, New York, and Philadelphia," written by George M. Whitaker, M. A., Sc. D., of this Bureau, and to recommend its publication as Bulletin No. 81 of the Bureau of Animal Industry series.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson, *Secretary.*

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By George M. Whitaker, M. A., Sc. D.,
Dairy Inspector, Bureau of Animal Industry.

PART I.—THE MILK SUPPLY OF BOSTON.

EXTENT OF POPULATION SUPPLIED.

The milk supply of Boston really means the milk supply of what is locally known as the "Greater Boston." This includes at least nine municipalities, the population of which is as follows:

Boston	560,000	Brookline	20,000
Cambridge	92,000	Revere	10,000
Somerville	61,000	Winthrop	6,000
Chelsea	34,000		
Malden	33,000	Total	840,000
Everett	24,000		

The territory supplied by the Boston milk system does not exactly conform to municipal lines, so that doubtless a part of the population in contiguous territory could also be properly added to the above. For example, one large wholesale establishment handling Boston milk does a considerable business in the near-by city of Lynn, which has a population of 68,000 and is not ordinarily included in Greater Boston.

Probably we are not far out of the way in assuming that the Boston milk supply reaches 900,000 people. Immediately about Boston and the several small towns and cities composing Greater Boston there are nine towns and cities, with 110,000 inhabitants; or, if Lynn is included, 178,000. Some of these places receive Boston milk. In many instances this territory is so thickly settled that the traveler, noticing the continuous line of houses, sees no division of one municipality from another. The number of cities and towns concerned has been overlooked by some writers on the question of the Boston milk supply, and has led to an exaggerated statement of the per capita consumption.

HANDLING MILK AT BOSTON.

From 80 to 85 per cent of the milk consumed in Greater Boston is transported by railroad and the remainder in wagons. In local nomenclature, "car milk" and "wagon milk" are common terms

for these two classes of milk. Of the railroad milk, nearly all is handled by five wholesale houses that do business on a plan which seems to be peculiar to Boston. These large wholesalers are locally known as "contractors." They contract for and buy the milk in the country, lease railroad milk cars, manage the transportation to the

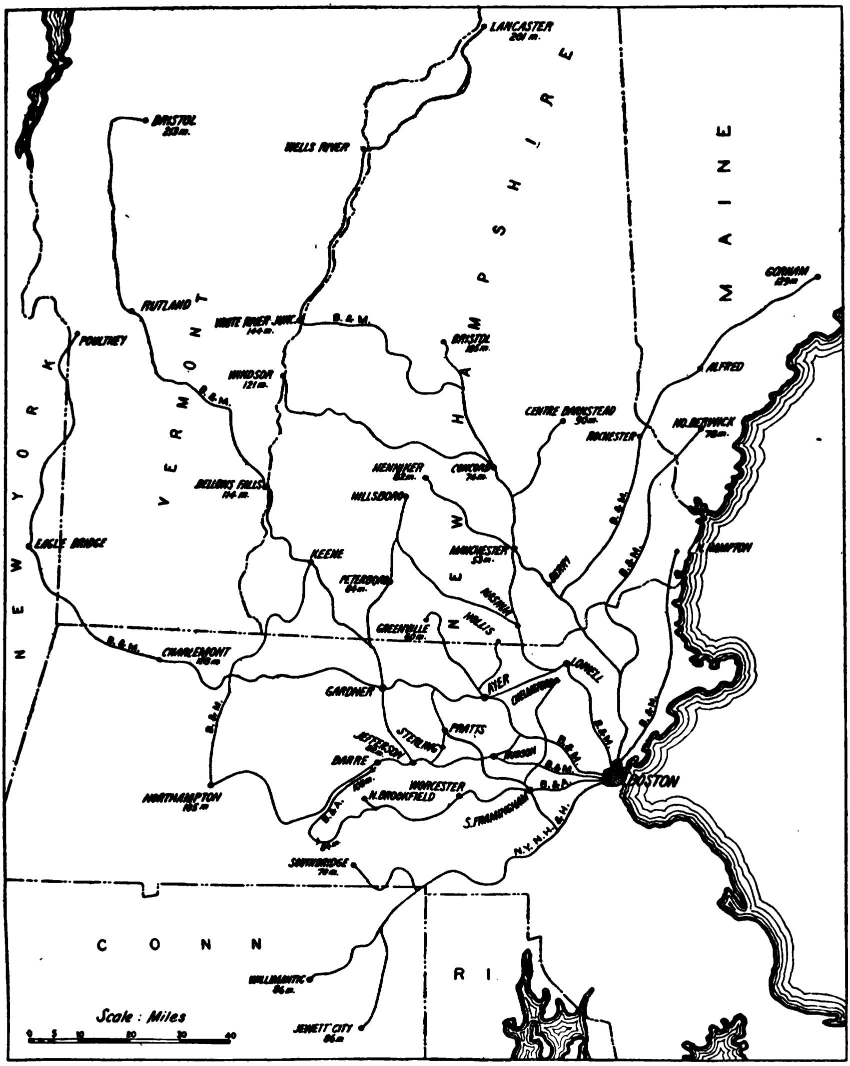

FIG. 1.—Map showing the source of Boston's milk supply.

city, and sell most of their supplies to peddlers for distribution at retail. Originally the contractors did an exclusively wholesale business, but of late years there has been a growing tendency to branch out into the retail business. A part of this business was forced upon them by their being obliged to take retail routes on account of debts

for milk due them by the peddlers; but recently this retailing of milk has seemed to be more of a deliberate policy. A few large retailers buy their supplies direct from the farmers, but the greater portion of the business of buying and receiving is done by the contractors. These five large wholesale concerns, though technically entirely separate, have a common understanding and practice in many details of the business. One person is at the head of three of the corporations, and it may be said that three officials could practically determine any question of policy for the whole business were they so disposed.

The cream supply of the city is not in such intimate connection with the milk business as is the case in New York. The contractors do a large cream business in connection with the milk trade, but much of the city cream comes from skimming stations entirely distinct from the contractors' system of milk collection and transportation. Large quantities of cream come to the city from Maine creameries, which were established primarily for the manufacture of butter; but they have drifted entirely into the cream business, and this has grown to such proportions that it has become necessary greatly to enlarge their plants. Skimming stations have been established, and the whole of their attention is given to the collection and distribution of cream.

The milk of the city is handled in 8½-quart cans, so that any use of the word "can" in connection with the Boston business means 8½ quarts, although many of the older cans are so battered that they do not hold over 8 quarts.

STATISTICS OF SHIPMENT.

MILK BROUGHT IN BY THE RAILWAYS.

For several years the contractors purchased an unlimited amount of milk from the producers on the agreement that they would pay the "milk" price for all that they could sell again and "butter value" for the surplus. Consequently the contractors reported to the farmers from month to month the amounts of their receipts and sales. The following table shows in round figures the magnitude of their business for a period of years:

Number of cans of milk received at Boston for several years.

Year.	Received.	Sold.	Surplus.
1891	7,000,000	6,000,000	1,000,000
1894	9,000,000	7,000,000	2,000,000
1896	10,000,000	8,000,000	2,000,000
1897	11,000,000	8,000,000	3,000,000
1899	11,000,000	9,000,000	2,000,000
1900	10,000,000	9,000,000	1,000,000
1901	9,000,000	8,000,000	1,000,000

The table shows increasing receipts up to 1897, when the highest point was reached—11,789,191 cans. Since then the receipts gradually declined until 1901, when they were 9,886,303 cans. This reduction was not due so much to a decrease in sales or in milk consumption as to a decline in the surplus. The surplus in 1897 was 3,059,619 cans and in 1901 as low as 1,430,166 cans. The sales of milk for the five years from 1897 to 1901, inclusive, were fairly uniform, ranging from 8,975,538 cans in 1900 to 8,456,137 in 1901. These figures, while accurate, do not in all instances correctly show the growth of the business; changes in the business of the contractors—such as, for instance, the buying out of competing peddlers—in some cases increased the figures, although no more milk was actually consumed. On the other hand, increased competition from outside dealers might lessen the contractors' business.

In 1902, because the producers insisted on a new way of making settlement for surplus milk, the contractors quit reporting the amount of the business. In 1904 the State railroad commission required the railroads to report their receipts of milk to the board, and statistics were again available. But, for purposes of comparison, it should be remembered that the contractors reported only their own business, while now the roads report to the railroad commission all the milk transported by them,

The following includes a report for nine months of receipts by the contractors in 1901–02:

	Cans.		Cans.
July	941,652	December	756,707
August	856,878	January	813,077
September	813,127	February	743,838
October	846,368	March	875,340
November	739,101		

The next table shows the receipts for nine months in 1904–05 as reported by the railroads:

	Cans.		Cans.
July	1,112,345	December	998,768
August	1,039,403	January	1,016,501
September	1,002,623	February	942,122
October	968,099	March	1,098,041
November	931,653		

The percentage of milk brought in by the different railroads fluctuates from month to month, but is substantially as follows:

	Per cent.
Boston and Maine	68
New York, New Haven and Hartford	20
Boston and Albany	12
Total	100

The amount of wagon milk entering into the Boston milk supply is entirely a matter of estimate. Some authorities estimate it to be one-fourth of the whole amount and others one-third. When the railroad milk amounts to 1,000,000 cans per month, the wagon milk probably ranges between 250,000 and 333,000 cans. Some of this milk is brought into the city by producers, and some is handled by middlemen, who buy their supplies from their neighbors and haul it to the city, where they sell it to hotels, restaurants, or retailers. Not much of this wagon milk is retailed in small quantities by those who haul it into the city. Most of it is brought into the city during the latter part of the night and is ready for the morning business. The wagons which transport this milk are not made specially for the business. Most of them have a canopy top. The cans are covered by a canvas, under which a lantern may be placed in the winter to prevent freezing, or a cake of ice in the summer for cooling. This wagon milk is gradually decreasing in amount as the agricultural land about the city increases in value and is more profitably devoted to market gardening than to dairying. Most of the wagon milk that comes to the city is produced within a radius of 25 miles.

PER CAPITA CONSUMPTION.

It is estimated that the contractors' receipts average 1,000,000 cans per month, and that the wagon milk is 250,000 additional. On this basis we have 1,250,000 cans as a monthly supply, or 10,625,000 quarts. This is 343,000 quarts per day, which, being divided among 900,000 (maximum estimate) people, would give 0.76 pint per day per capita; divided among 800,000 (minimum estimate), we have 0.86 pint per capita. Either figure is within reason.

SYSTEM OF PAYMENT.

The price which the contractors pay the producers for milk depends upon the distance that the milk must be transported. The city price being fixed, the following is the scale of discounts per can of 8½ quarts:

	Cents.
For stations between 17 and 23 miles from Boston	6
For stations between 23 and 36 miles from Boston	7
For stations between 36 and 56 miles from Boston	8
For stations between 56 and 76 miles from Boston	9

And 1 cent more for each additional 20 miles.

This discount includes not only the freight, but the expense of handling the milk and the contractors' profits. There are so many factors which affect the expense that the producer has no way of knowing exactly the cost of transportation alone. The cars are leased at a fixed rate by the year, and if a car is completely filled the cost of freight

per can is much less than when a car is only partly filled. Again, the contractors have ice houses at the largest shipping stations and furnish their own supplies in a large measure, reducing the cost of refrigeration to a minimum. The inability of the producers to ascertain the contractors' profits and the exact cost of transportation sometimes causes discontent.

We have alluded to the old-time method of settling for surplus milk by paying for its butter value and to the abandonment of this plan for another one. The change was brought about primarily by the influence of the producers' organization. When the producers complained of the old system, with its uncertainties and the opportunity for distrust, and asked for a uniform price for all milk whether surplus or not, the contractors replied in effect that they would take their chances if the price was cut 2 cents per can. This was allowed by the producers, and this 2 cents is now spoken of as a "carrying charge." For instance, the Boston price of milk for the summer of 1905 was 37½ cents per can. To get at the figure which the farmer received, deduct from this 37½ cents the 2 cents for the "carrying charge" and also the proper discount, as shown above. The contractors also asked that the producers exert themselves to bring about more even production, so that the supply would be more uniform in quantity and the contractors be saved the large loss incident to paying for surplus milk that must be made into butter. After much thought this plan has been devised: Each producer, at the beginning of each six months price period, states the amount he intends to produce during the coming six months. If the total of the amounts exceeds the probable demand, each producer is cut down pro rata. Then it is understood that the price agreed upon for the period shall apply to that rating, with a range of one-sixth in either direction, and that the farmer shall be paid 1 cent less for all his shipments for each additional one-sixth variation. To illustrate: If a farmer is expected to produce 300 cans in any month, he can drop to 250 or increase to 350 and get the full price (37½ cents less the two discounts), but if he falls below 250 or runs over 350 he gets 1 cent less for all the milk he ships. When the next limit is passed the price on all his shipments drops another cent.

CANS.

The cans most used in the Boston milk business are made to contain 8½ quarts. The fraction is added so that there will surely be 2 gallons when the cans become battered from hard usage. As Boston is the commercial center of New England, this style of can is generally used in the smaller cities and towns of this section, although the Providence, R. I., can contains 10 quarts. These 8½-quart cans are

convenient in loading a wagon or car, as the handle is on one side and one man can easily take two cans in each hand. They are also convenient for the small producer, who can ship milk to the city, although his dairy produces but one can. These cans go into the car as they leave the dairy and at the terminal are turned over to the city dealer; hence they are convenient also at the city end of the line for delivering to the small grocer or restaurant keeper, who may not care to handle more than a can or two. Occasionally one may see on a milk train or about the depot of some wholesaler a few of the New York 40-quart cans, which are used as carriers for milk for the contractors' own retail trade; but these cans are not popular among those who have to handle them after having been accustomed to the smaller cans. Some of the contractors are experimenting with a new-style can. It has somewhat the shape of the New York can, but has just 2½ times the capacity of the regular cans—21¼ quarts. It is not so heavy as the 40-quart can, is more easily cleaned than the 8½-quart can, and has a wider top. Some new cans recently adopted experimentally to a limited extent contain 8½ quarts, but have a concave bottom, so that all the milk that drains down the sides, after the cans are emptied, settles at the center of the bottom of the can. This makes washing easier, as there are no corners to cause trouble.

CAN STOPPERS.

For years the stoppers of the cans have been wooden plugs. These have the advantage of sealing the can perfectly, for a tap with a hammer drives the plug in so tightly that the can is almost hermetically sealed. If there is need of piling up the cans in tiers, or "stacking" them, these wooden plugs make a firm and level surface for sustaining the tier and are not injured by the added weight. The convenience of this kind of stopper and the fact that it is the kind used in Boston has led to its adoption all over New England in the milk business of the other cities and towns.

Modern knowledge of bacteriology and the effect of bacteria on milk, however, has shown the undesirability of such stoppers even when apparently clean. In time they became so battered and full of cracks that it is impossible to sterilize them. A stopper was taken from a shipping station where the stoppers were treated with steam so liberally that they had all the appearance of being fully sterilized. Any ordinary inspection would have passed it as being perfectly clean and dry. It was examined by the bacteriologist of the Dairy Division, who took scrapings from the end and from some of the cracks with a sharp knife, and from these made gelatin plates in the usual way. Although a dilution representing 0.0005 gram of wood was used, the plates were all liquefied by bacteria. This

indicated that the surface of the wood contained a large number of bacteria, the presence of which in milk would be undesirable. Another stopper taken from an empty can in a milk car was a fair sample of many of the stoppers that are returned every hot summer day to the farmers for their wives to wash. The bacteriologist reported the ends of this stopper and the cracks to be completely covered with mold. The mold was removed from the end of the stopper by scraping, but the cracks were so thoroughly impregnated with molds that no examination of them was attempted. A drop of the first dilution added to a flask of sterile milk curdled the milk in twenty-four hours, with digestion and gas formation. The gelatin plates gave the following results per gram of wood:

Bacteria digesting milk	2,760,000
Bacteria producing gassy fermentation	680,000
Remainder, mostly lactic-acid formers	52,240,000
Total	55,680,000

What happens to such stoppers in the hands of the farmer? They receive treatment varying with the disposition of the farmers and their wives. In some cases the outside of the stopper is washed in the ordinary way of washing any utensil; in others the stoppers, after being washed, are placed in boiling water. In one instance an unusually neat woman was found who placed the stoppers in a kettle of water and boiled them. A stopper was taken from a clean dairy which seemed to be well managed. This was believed to have been given a little more thorough treatment than the average—certainly no worse. The stopper appeared absolutely clean and was dry. Gelatin plates were prepared in the usual way and the count showed a total of 90,000 bacteria per gram of wood—that is, the end wood which would come in contact with the milk. This stopper had been "scalded" and was probably as clean as it was possible to make it with ordinary farm accommodations.

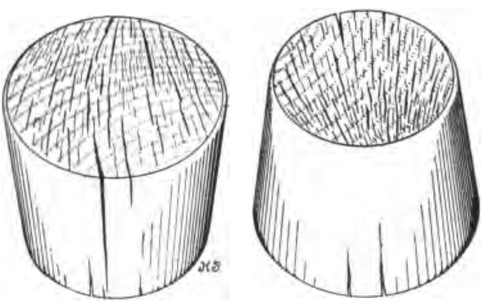

FIG. 2.—Wooden plug used in the Boston milk can.

The board of health of the city of Holyoke, declaring that the wooden plugs are a source of filth and cause of sickness, has prohibited their use. The milk inspector of the city will not license persons to deal in milk unless this order is complied with.

Figure 2 illustrates the characteristic wooden plug, or stopper, for

the typical Boston 8½-quart can. The milk contractors or wholesalers supplying the Boston market, realizing the undesirabiltiy of these stoppers from the sanitary standpoint, have experimented with several forms of tin covers. They are more costly than the wooden plugs, and to prevent loss they are attached to the can by a short chain. These tin covers answer fairly well the purpose of presenting a level top for convenience in piling up, or stacking; but they meet with general disfavor by the trade. There is a depression in the top to hold the ring to which the chain is attached. This catches dirt, which eventually finds its way into the milk. Tin covers do not fit the cans so tightly and firmly as do wooden plugs, hence there is more or less trouble from leakage. To obviate this some handlers of cans try to make the tin covers hold better by driving them on with a hammer, as they do the wooden plugs. This operation results in cracking the tin, and these cracks harbor dirt and sour milk, and the conditions are sometimes as bad as where the wooden plugs are used. Furthermore, the covers dangling from chains are always in the way when emptying the cans. Tin covers with convex tops are impracticable in the case of 8½-quart cans, as they do not allow placing in stacks, or tiers. Such covers, however, are satisfactory on 40-quart cans. Some tin covers were found with a hole punched in the top and bottom to allow air to escape when placing the cover on the can.

A year ago one might truthfully have written that the trend in Boston was toward the tin covers. They have so failed to win favor in the trade that now sentiment is changing the other way and the wooden plug is again most favored by the peddlers of milk. To render the use of the plugs less objectionable, some of the dealers are using parchment paper between the wood and the milk. A small sheet is placed over the top of the can when it is filled with milk and then the plug is driven into place.

The newest thing in the Boston milk business is a recently invented machine for taking dents out of cans in a way that does not start the seams or crack the tinning. This device is of advantage from a sanitary standpoint, for it restores a smooth surface to the inside of the can, thus enabling it to be more readily cleaned. The machine is of advantage financially to large dealers, for it adds half a pint on an average to the capacity of each can.

WASHING CANS.

The cans used in the Boston milk business are usually washed at the farmers' homes. The empties are returned from the city without even being rinsed; and when the producer takes them from the railroad to his dairy, the washing frequently devolves on his wife or daughters, adding a considerable burden, while the work can not

always be done thoroughly. Whether or not the contractors should return clean cans to the producers is a question which has been discussed at the meetings of milk producers for many years. The contractors' side of the case has two points; the first is the expense. The contractors say that they are now obliged to keep about five cans for every can of milk shipped, to allow for the number going and coming to and from the country and for those held over by dealers and by farmers. As the empties received from the peddlers are loaded directly into the milk cars while the latter are standing at the milk stations for unloading, there is no time then for washing. In order to have them washed it would be necessary to retain them in the city twenty-four hours, thus necessitating another set of cans. The contractors claim that this would be an unnecessary and burdensome expense. They further claim that, no matter how clean a can may be washed in the city, it must be scalded and aired in the country before it is again fit to hold milk. They argue that if the farmers receive nicely cleaned cans they will be careless about the scalding and airing, and the milk will reach the city in much worse condition than it does at present. The farmers' side of the case is that washing cans belonging to the contractors is not a necessary incident of milk production; that the work can better be done on a large scale by machinery and with plenty of hot water and steam; that sometimes cans are returned in a repulsively dirty condition, and that cans which have stood for days in a restaurant or grocery store, possibly used as slop cans during that time, are in a condition that the farmer should not be called on to remedy. Judging from stories told at some producers' meetings, cans containing restaurant slops, kerosene oil, and decaying masses of sour curd are very common. It should be stated, however, that most of the cans are returned quite promptly after they are emptied. One large shipper told the writer that although he thought all cans should be returned clean, he had no trouble with those which are exceptionally bad; if he had one which contained what would not readily rinse off, he simply declined to use it and returned it to the contractors. A common sight about farmhouses, where milk production is a specialty, is a row of cans inverted on racks for airing after having been washed.

A third factor, which is now coming prominently to the front, is the work of medical men and boards of health. These are alert for the improvement of the milk supply and call attention to faults in the milk situation. Conditions which were once considered good enough are now regarded as intolerable, owing to the information which modern bacteriological investigations have made available. The contractors admit, by implication at least, that conditions which formerly existed were not perfect. They are now experimenting with different kinds of cans and making other changes and improve-

ments. For instance, with the can holding two and one-half times as much as the common 8½-quart can it is found that fewer are required in proportion to the business done, and that these can readily be washed and sterilized before being returned to the farmers. It is also found that the milk comes to the city in better condition in these cans, furnishing a selfish argument for a gradual change in the system of returning dirty cans to the farmers.

In September, 1905, the producers agreed to take one-half cent less per can if the contractors should return clean cans to them.

CONDITIONS AT THE FARMS.

Boston has no system of certified milk, and none of the large contractors make a specialty of milk of extra quality at extra prices; but several large producers who can control all the conditions of production sell milk above the average in percentage of fat and also in cleanliness, receiving an adequate price for such quality. Neither has Boston any large firm of wholesalers who can and will make exacting regulations. Still, the Boston contractors are watchful over their supply, and have a system of inspecting stables and of cautioning producers when bad conditions are found. The contractors do some educational work also in giving instructions as to the proper manner of caring for milk, especially as to the importance of promptly removing it from the stable and cooling to at least 50° F., as the first half hour in the life of the milk is the most critical. The contractors require the producers to have an ice supply, and in one instance a contractor gave each of his producers a thermometer. At meetings of boards of health the carelessness of the farmers in the care of the milk is a matter of emphatic criticism with much of truth in the statements, especially in view of the increasing information as to the way in which milk should be handled; but, on the other hand, there are many intelligent, conscientious farmers who are painstaking and who produce a clean article.

Further attention is given this subject under the heading "Official inspection" (pp. 29–31).

CARRYING MILK FROM FARM TO CARS.

The first step in the transportation of milk is from the farm to the railroad station. This work is usually done by the farmer. There are no wagons for transporting milk from farm to cars that are constructed with the special idea of keeping the milk cool in summer and from freezing in the winter. Every conceivable kind of vehicle is used, from top carriages to very rickety wagons. In two instances the writer has seen wheelbarrows used. Often it is the daily duty of

the farmer's boy to drive the load of milk to the railroad, and sometimes the wife or daughter does this work. Average dairies produce from fifteen to twenty cans per day, which is not a large load.

When the milk leaves the farm it is supposed to have been cooled down to about 50° F., the exception being morning's milk produced near the railroad, which is taken at once to the car. When placed on the wagon for transportation to the station, it is carefully covered with a horse blanket or piece of canvas. When the drive is a long one a cake of ice may be placed under the cover in the summer or a lighted lantern in the winter. The average length of haul where the farmer carries his own product to the railroad is 3 or 4 miles. Where the production is small and the producers live greater distances from the cars, one farmer frequently collects the milk for a number of his neighbors. The customary charge for such collection is 2 cents per can, although in some cases as high as 3 cents is paid if the route is a long one.

When milk is taken to the station by a collector, although the affair has the semblance of a cooperative venture, the contractors exercise a supervision or control over the collection for the purpose of insuring reliable, punctual service, and warranting the collector enough permanent business to pay him for his labor and investment. He must have a strong wagon and good horses. As he must usually travel about 15 miles a day, in all kinds of weather, seven days per week, and on all conditions of roads, he can not do much other work, and so he must be sure of getting enough from hauling the milk to pay him for keeping a team exclusively for this business. Furthermore, he must be a reliable man, who will surmount obstacles and be on time with his load, regardless of storms and bad roads. Sometimes the haul by wagons is as long as 10 miles, making 20 miles of travel for the round trip. At one railroad station the writer met a driver with load of 94 cans. In the flush season the number is twice as large. He said that he collected from 32 dairies, which at that time were producing from 2 to 11 cans each per day. He lived 4 miles from the station, but had to drive 9 miles to take in all his dairies, making his daily trip about 13 miles. The milk leaves the farm at 6 or 7 o'clock in the morning, according to distance from station and from Boston. Where the start is much earlier, the milk of that morning is usually not taken.

The temperature of the milk when it arrives at the railroad station is of some interest. The writer took the temperature of a number of lots of milk received at Barre Plains and Old Furnace, Mass., when the air temperature was 75° F., and found that it ranged from 62° to 68°. One firm of contractors goes to the trouble of having the temperature of the milk from each dairy taken (morning and evening) by its agent at the railroad station, and the record sent to the city along with the milk. Regular blanks are prepared on which the

number of the dairy is entered and against it the two temperatures. The following is the temperature record of the milk put on the car at Canaan, N. H., on the morning of August 17, 1904:

° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
54	54	56	52	58
56	56	54	54	56
58	56	58	58	46
46	54	56	58	56
54	56	52	54	52
44	44	48	48	54
52	56	54	54	52

That morning's shipment from Fremont, N. H., was of the following temperatures:

° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
58	54	54	56	56
56	50	56	54	54
56	51	51	58	58
58	58	59	58	56
54	56	58	58	50
58	56	50	58	58
58	------	------	------	------

The temperatures of the shipments from Barrington were as follows:

° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
69	57	62	62	64	63
63	58	58	48	48	56
51	44	58	58	53	56
48	62	45	64	74	52
50	67	58	52	72	------
54	64	64	50	66	------
57	50	------	48	60	------

HANDLING AT THE RAILROAD STATION.

Most lines of railroad over which milk is transported have at each station a raised platform near the track and level with the car door. This platform is of varying size; perhaps 20 feet square is a fair average. In some cases a roof is built over it for the protection of men and milk. The farmers reach the station a few minutes before the train is due and unload the milk on the platform, or on the ground near where the train will stop when there is no platform. In all cases the farmers load the milk into the cars. In some few cases the arrangement of tracks and sidings is such that the milk has to be lifted from the ground and carried across one or more tracks. The milk seldom waits long at the station. It arrives just before the train, is quickly transferred from the farmer's wagon to the railroad car,

and does not have opportunity to be much affected by the weather if it started all right as to temperature and was properly covered in transit.

Ordinarily when the farmers take the milk to the car they get the empty cans to carry home for the next day's supply. Sometimes these are thrown from the train to the platform or ground the previous afternoon, when the milk car or train is making its outward run. Sometimes they are unloaded on the inward run, in the morning, before loading the full cans; then again, the empties are thrown from one door while the milk is loading into the other. Frequently the empty cans are tied in bunches so that a half dozen can be handled with one throw. These empty cans are, as a rule, unwashed, and on the farmer's return to his home, cleaning the cans is the first duty of those who do the work of the dairy.

MILK CARS.

Most of the milk shipped to the Boston market is transported in cars built especially for the business, which are peculiar to Boston. A small amount of milk is shipped by express on passenger trains; some of this is for hospitals from selected dairies, and some is for small peddlers who buy direct from the producers. A further small amount is thus shipped from fancy dairies to some agent for distribution direct to customers who pay an extra price. A small amount of milk also comes into the city in refrigerator cars on fast freight trains, and a small amount is loaded into baggage cars on branch lines for reloading into the regular milk car at the junction point. But, speaking in a general way, practically all of the regular supply is transported in the regulation milk cars, which are much alike on all the roads. The cars appear superficially much like common express cars, except that each one has a small window or two between the two side doors, and has the word "Milk" painted upon it. Occasionally one sees a car with a narrow door in the middle instead of a window. The cars have the usual end doors for the convenience of trainmen. Most of the milk cars are 48 feet long, inside measurement. In the center is an office, usually 8½ by 9 feet. The office has two windows on each side, except in a few cases where there is a door. Each car has eight closets. These are 3⅓ by 4 feet, and with two shelves, accommodating three tiers of cans. Each tier has 30 cans, and thus each closet holds 90 cans. This makes a closet capacity per car of 720 cans. There are two doors, 3½ feet wide, opening to a space in each end of the car for receiving the cans, storing and breaking ice, and doing the necessary work of handling cans. When the closets are full, some cans are placed on the open floor space. Nine hundred and sixty cans is the usual carload.

There are some minor differences as to detail in different cars. For instance, on some roads the milk cupboards hold 105 cans each and the carload is 1,000 cans, or 8,500 quarts. But in a general way one car is a fair type of all of them. Years ago the railroads paid but little attention to the amount of milk carried in a car. The car was leased to the contractor, and no questions were asked as to the load that he put into it. More recently there has been a disposition to keep a supervision over the amount shipped. Formerly as high as 1,400 cans were sometimes placed in a car without any fault being found. Now the roads require daily reports from station agents as to the amount loaded at their several stations each morning. If the load exceeds 960 or 1,000 cans (according to the road), the contractor is compelled to pay for an extra car. The contractors pay by the year for the cars, on varying plans, which makes it difficult to get at the exact cost of transportation. Further than this, a car starting 50 miles from the city may run a quarter full a third of the way, half full a third of the distance, and completely full the last third of the trip, thus increasing the difficulty of computing the cost of transportation. If the contractor could put in 200 or 300 additional cans for a portion of the distance in time of flush production, it would be an advantage to him, but would greatly decrease the possibility of estimating accurately the cost of transportation.

The contractors plan to have an ice house, when possible, at the village from which the car starts and located near the tracks. They fill this themselves and hence have a handy supply of ice at cost. When the car starts it has from 2 to 4 tons of ice, according to the length of run. The smaller amount is the more common. At a station where milk is received, it is loaded by the farmers into the open spaces at each end of the car, and on the run between stations the carmen (in the employ of the contractors) are kept busy packing these cans into the cupboards or closets, and, in the summer, breaking up the large cakes of ice and shoveling the pieces onto the cans and working it into the vacant spaces. When one of these closets is full the door is closed and kept so until the car reaches the city. In addition to the trainmen (two to each car) employed by the milk contractors, the railroad company sometimes has a special trainman besides those on duty in the passenger cars. The milk cars are piped for steam heat in winter.

FREIGHT RATES.

The Massachusetts statutes require that all freight rates shall be fair and proportionate, and that all shippers shall have equal advantages, and the law gives the railroad commissioners full power to fix rates for transporting milk. In practice this applies only to small shipments, for the large contractors are always able to reach some

agreement with the railroads on car lots, and never appeal to the commissioners; but there have been a number of interesting appeals to the latter by smaller shippers, their complaint being that discrimination was shown in favor of the large wholesale shippers by the system of leasing cars, and that the small shipper could not get milk iced in transit. The commissioners decided that it would be unjust to compel a railroad to run a fully equipped separate milk car to give a shipper of 20 cans per day as good accommodations as the shipper of 1,000 cans, but ordered some arrangement to be made between the railroad and the contractor by which the milk of the small shipper could go in the contractor's milk car. As a result, at a few stations milk tickets were sold by the railroad to the producer. These were received by the contractor with the understanding that the milk would be transported and properly cared for in his car. But the rate was considered too high and complaint was made to the commission, which entered into a careful computation of what might be assumed to be the cost to the contractors of transporting milk in car lots. To this was added a sum which the commission considered a fair and just increase for retail transportation, and ordered that this sum should be the retail rate for shipping milk. Then the milk producers asked for a retail rate from every station from which milk was shipped. This was opposed on the ground that the commission had no right to rule on hypothetical cases and could fix rates only where there was milk to be shipped. But the commission overruled this, and made rates as requested by the producers. Very little practical use, however, has been made of these rates.

It should be understood that all this applies only to shipments originating in the State. Much of the milk coming to Boston is the subject of interstate commerce and under the jurisdiction of the Interstate Commerce Commission in case of dispute, rather than the State commission.

MILK ROUTES.

Forty-five to fifty milk cars, such as those already described, reach Boston every day. They are largely attached to passenger trains which run as slow accommodation trains and are popularly known as "milk trains," although they are on the regular time tables as ordinary passenger trains. In two instances the milk cars are run in special and exclusive trains. The cars leave the country terminals in time to reach the city soon after 10 o'clock a.m. In a general way it would be accurate to say that the cars start about 5 or 6 o'clock in the morning and are four or five hours on the road, but in some cases the cars start as late as 7 o'clock. The trains stop to pick up milk at stations along the road until they get within three-quarters of

an hour to an hour of the city, so that milk is collected until 9 o'clock on some routes. Why the cars are run at this time instead of running in the night we do not know.

The milk car, as a rule, brings to the city the milk of that morning and the previous night; but when the train leaves too early to make this convenient, or when the collector has to call too early in order to connect with the train, the milk of the previous day is shipped and the milk of that morning is held over. The aim in the Boston method of handling milk seems to be thorough icing rather than rushing it through to the consumer in the shortest possible time.

Some of the contractors have butter factories and cheese factories in the country entirely separate from their milk business, but giving them control of extra milk for an emergency. Each of the contractors except one has a station on his route where any surplus can be left and where milk from the longer runs can be iced and left overnight, and from which extra milk can be taken in anticipation of an unusual demand. One collecting firm has two shipping stations patterned after the New York system, at which milk is received from the farmers in the latter's cans, clean cans returned, and milk paid for by weight. Here the milk is aerated, mixed, cooled, and canned.

A notable exception to the system of running cars exists in the case of a milk car which leaves Gorham, Me., at 8 in the morning and reaches Rochester, N. H., too late to get into Boston in time for the usual sales; it remains in Rochester six hours and goes to the city on a fast freight in the night. Another exceptional car leaves Willimantic, Conn., at 3 p. m., and reaches Boston at 6, remaining on the track overnight for the early morning trade.

A ROUTE IN DETAIL.

The station at Northampton, Mass., is the starting place; time, 5.50 in the morning. The train consists of a combination baggage car and smoker, a common passenger car, and a milk car with a few cans of cream and milk that came down from Keene, N. H., the previous afternoon. In fourteen minutes we stop at Amherst to take on 20 cans of milk, and to leave a cake of ice and a few empty cans. In eight minutes more the train draws up at a flag station where 15 cans are loaded from the station platform and several empties thrown out. The next stop is at Belchertown. Here eight one-horse wagons are hitched promiscuously to all kinds of available objects about the station; and 120 cans of milk are loaded, while the passengers are increased by one. Two or three miles farther on the train draws up at a highway crossing where there is a small platform and the usual shelter. Here nine single teams with common wagons are hitched to near-by fences and bushes, while the farmers quickly transfer 150

cans of milk from the platform to the car. Among the drivers of the teams are three girls. It is now 6.35 and we have reached Bondville, where there is a repetition of the scenes at the previous station and about the same amount of milk loaded. The farmers have loaded the empty cans before the train arrived and some begin to drive away before the train leaves, reading their morning papers as their horses jog slowly along.

Some 4 miles farther along we come to another crossing where a dozen teams are hitched by the roadside. Here 175 cans are transferred from the shed to the train by the farmers, while the same number of empties, tied in bunches of 10 each, are thrown from the other door of the car. This not being a regular stopping place for the trains other than this milk train, these empty cans were not left here the afternoon before. Just as the conductor is raising his hand to signal to start, a belated producer hurries his team to the platform, and has just time enough to put 8 cans (his day's product) on the train before it gets under headway. At Ware, an hour from Northampton, we come to a manufacturing village, where there are more evidences of life and a few passengers board the train. Though there are no signs of milk production in the foreground, 100 cans of milk from near-by territory are taken on the train. At Gilbertville, about 4 miles beyond, one of the largest collections of farm wagons yet seen is grouped about the station and the milk on the train is increased by 200 cans.

As the train has been moving on, the men on the car have had all the work they could do between the stations in stowing the cans into the closets and packing broken ice about them. The little rooms have been filled and some cans have been stacked on the floor of the car with boards between the tiers of cans, while broken ice has been packed about them. The car is full.

At New Braintree only a few milk wagons are in sight, and these are for the most part headed for home. This is accounted for by the fact that they have loaded their day's supply in a car which is standing on a siding. Our train backs up to this car and is coupled to it. The next station is Barre Plains, but the train takes no milk here. This is a junction and the shipments go to the city by another line, controlled by another contractor. It is now 8.30 and we are at Barre. About 50 cans are loaded at this station. As many more are put on the train at Colebrook. The section of country through which we are passing, including Barre, New Braintree, and contiguous towns, has the reputation of shipping more milk over the two lines than any area of similar size supplying the Boston market. At West Rutland there is a repetition of scenes already reported—the characteristic milk platform and shelter, the group of wagons, and the loading of the cans. Here is noticed the first two-horse team

seen on this ride. At this station is seen another belated farmer who barely gets his 7 cans of milk on the train before it starts. At Rutland 61 cans are loaded, and 2 are set off bearing a pink slip held in place by the wooden stopper. This slip reads: "Sour—Returned." Each dairy has a number; these numbers are printed on gummed paper and supplied to the farmers, who are required to keep one glued to each wooden stopper. In this way the car men can keep track of the shipments from each dairy and correctly report the amount of milk. When sour milk is returned, the number on the can shows from what dairy it was taken.

It may be remarked that this return of sour milk is a cause of much dissatisfaction on the part of the farmers, who claim that when the milk is delivered at the station to the agent of the contractor their responsibility should cease. The contractors claim that milk should be delivered to them in good condition, but that the nature of milk is such that its condition can be determined only by premature souring; and that if a can or two of milk sours sooner than other milk kept under similar conditions that fact is proof of its having been originally delivered in an improper condition. The farmers retort that, even if the contractors' statement of an abstract proposition is correct, the concrete application makes the contractor prosecutor, judge, and jury, and gives the farmer no opportunity to satisfy himself of the correctness of the facts.

Nine o'clock, and Muschopauge station is reached and 47 cans loaded and 4 with the pink slips set off. Five miles beyond, at Quinapoxet, 60 cans are loaded and 1 can of sour milk set off. Oakdale is reached at 9.30. Here a two-horse team having 60 cans is driven alongside of the car and unloaded directly into the car, while about 20 cans are picked up from the station platform. At Berlin a dozen cans are added to our load, 17 at Hudson, 10 at Wayside Inn, and half a dozen at South Sudbury, which ends the taking on. This place is only 20 miles from Boston and is reached at 10.22.

At Waltham, 10 miles from the city, 10 cans are left for some local dealer. At Cambridge three wagons are backed up to a milk shed and between 250 and 300 cans are unloaded, while a few pink-slip cans are placed on the car to go back into the country in the afternoon. A mile farther, and just before entering the passenger station, the train stops and the milk cars are disconnected. We move on to the station, while a switching engine takes the milk cars to one of the milk-receiving stations. The run of 105 miles has been made in five hours and twenty minutes.

ANOTHER MILK ROUTE.

This is a different kind of route, and the ride over a portion of it may be described as follows: We reach the station of the rail-

road at Wilton, N. H., about 7.30 a. m. A milk car is on the siding and a procession of teams stands in line, each farmer waiting his turn to reach the car door and unload his daily product into the car. The longest drive for a farmer is about 6 miles, and many farmers live within 2 miles of the railroad. About 300 cans are daily loaded here. This car has closets that hold 90 cans each, 30 on each shelf, and it takes a supply of ice amounting to 4 tons each day. For twenty minutes the work of loading proceeds, when a locomotive whistle is heard in the distance, and at 7.55 a train appears, composed of two milk cars and one ice car. One of the milk cars is from Peterboro and one from Hillsboro. The Wilton car is connected, giving the train a third milk car. After a run of a few miles we stop, and 120 cans are loaded. The same thing happens at Milford, and small supplies are taken at several minor stations. Nashua is the next stop, and here a whole carload of milk from Henniker is attached to our train. It is a short run to Lowell, Mass., and just before reaching it a stop is made and two more cars are picked up—one from Sterling, Mass., and one from Hollis, N. H. The train with its six cars runs as an express to Boston and is promptly switched around to the milk depot of one of the largest contractors, reaching there about 10.15 a. m.

The man in charge of the train is an agent of the contracting corporation, who receives reports from each carman en route. He is kept busy with his accounts, and has them classified and ready to turn over to the clerical force in the Boston office as soon as the car arrives.

The milk on this train is all of the evening before and that morning. The evening's milk is all carefully cooled, but most of the morning's milk is produced so near the railroad that the management of the milk company believes it suffers no harm during the few moments it is on the way from the dairy to the car, where it is carefully packed in ice.

THE MILK IN THE CITY.

AT THE RAILWAY STATION.

When the milk reaches the city most of it passes immediately into the hands of the peddlers, or retailers, who are to distribute it. Many of these are at the platform on the arrival of the train to take their supply as soon as it comes out of the cars. Some peddlers take milk from the same dairies, so far as it is possible, day after day. They take the milk in the cans in which it was transported, so that the milk goes in the same cans from producer to peddler. For an hour or so the city milk depots are scenes of great animation

as the cars are unloaded and the empty cans transferred from platform to car. As soon as this work is done the cars are hauled out ready to be made up into their respective trains for return to the country. When the peddlers leave the milk station with their loads of milk, they go for the most part to their several places of business, where the milk is poured into mixers to make it uniform in quality and then bottled for delivery to customers. These bottles of milk are then put on ice to be kept until early the next morning, when the milk is distributed, often before people are awake, the bottles being left on doorstep or in some other convenient place. Where dealers have customers who take whole cans—like hotels, restaurants, stores, etc.—these may be delivered in the early afternoon of the day they are taken from the car. Hence it is sometimes possible in an afternoon to buy milk at a grocery which is fresher than the regular family supply. The family supply could be delivered the day before if it were not for the feeling among housekeepers that morning is the time for milk to be delivered. If an afternoon delivery would be tolerated, much milk could be delivered the day it is produced.

Each contractor's milk-receiving station is fitted up with sheds and platforms adjoining the railway tracks. It has, in addition, commodious and up-to-date buildings for offices, vats for holding surplus milk or for carrying milk over for another day's use, also a complete butter-manufacturing outfit for utilizing any surplus milk, and in one instance a cheese plant.

THE PEDDLERS.

The places of the milk peddlers were in many instances very filthy and insanitary. The stables and the milk room were frequently close to each other, and, besides this, there had been general untidiness. With increasing knowledge of the effect of such insanitary conditions, the health authorities have become more active and vigilant, and this has resulted in great improvement in the condition of milk "stables" and milk houses.

Many retail milk routes are falling into the hands of the contractors. This sometimes happens through the necessity of taking them in payment for debts, and sometimes through a policy on the part of some of the contractors to control the retail trade and to eliminate the second set of middlemen. Some of the contractors do both a retail and wholesale business in the same corporate name, while others take a different name for the retail part of the business. In some instances a contractor selects some of his best milk for his own retail trade; then, by pasteurizing or filtering it, he can place on the market an article of more than average quality. Where this

is done the contractor's milk depot contains more machinery and other equipment than is usually the case.

DESCRIPTION OF A CONTRACTOR'S RETAIL DEPARTMENT.

On the arrival of the milk train in Boston a large can (a mixer) is placed in the car, and connected by hand couplings and a short piece of pipe with what might be described as a hydrant in the platform. The milk is emptied from the milk cans in the car into this mixer. When a can is emptied it is placed bottom side up on a rotary rack inside of the mixer to drain. The rotary rack holds about a dozen cans, and by the time it is full the can first put in is well drained and is taken out and returned to the car, while another empty is placed in position, so that for every can taken out another is put in till the car is emptied. The milk is pumped from this mixer to a cooler in the upper story, where it is run over pipes filled with ice water. From this it runs to a strainer. This strainer is a tank with wire bars across the bottom. Cheesecloth is placed on these and absorbent cotton on top of this, then another layer of cheesecloth. This is followed by still more wire bars to hold the cloth and cotton in position. When this strainer has been in use for some time another is substituted, the cotton being stained quite dark with the manure and other filth which have been taken from the milk. The word "strainer" is used because that conforms more strictly to the language common in the dairy, but this apparatus may more accurately be termed a filter. From the strainer, or filter, the milk flows to a glass-lined tank containing 2,200 gallons. There are two of these tanks in the room. The milk in these tanks is continually stirred by an agitator, resulting in a perfectly uniform article. The room has an asphalt floor and the wooden walls are covered with enamel paint, so that the premises can be kept scrupulously clean. From these tanks the milk flows to fillers in the room below, from which glass bottles or tin cans of various sizes are filled for the next day's trade. The milk averages 12.75 per cent solids—3.80 per cent fat. The glass milk bottles are put into boxes and broken ice is packed about them. The pipes through which the milk is conveyed are made of tin-lined copper and are kept scrupulously clean. After the day's work is done they are filled with water and sal-soda, which is allowed to stand for a while; then they are flushed with clean water, and steam is driven through them. They are put together with "unions," so that every part is readily accessible. The place has up-to-date accommodations for washing and rinsing cans and for cleaning and sterilizing bottles. A large business in modified milk for babies and invalids is also carried on.

One of the large Boston dealers who puts on the market a superior quality of milk publishes a booklet in the Italian and Hebrew languages, as well as in English, descriptive of his methods and advertising the product.

CREAM.

The cream trade in Boston is supplied to some extent by the milk contractors, their supplies being received from skimming stations in the country and transported in their milk cars; but they do not have such exclusive control of the cream business as they do of the milk trade. A number of creameries are making a specialty of cream production and are sending considerable quantities to the city by express. One large Maine corporation has two creameries in that State where milk is received, pasteurized, and separated, the cream being shipped to several of the larger New England cities. The milk is collected by railroad for these creameries, carefully iced in summer, and shipped in charge of men on each car. The cream for Boston leaves the creamery at 5 p. m. and is forwarded by fast freight in refrigerator cars. It reaches Boston at 6 o'clock in the morning. It is carried in 40-quart cans, covered with a flat tin cover made perfectly tight by a rubber collar. The cover is fastened firmly in place by a little clamp. It is sealed with a lead seal similar to that used on the doors of freight cars. This prevents any tampering with the cream in transit. When the cream reaches the city it is hauled on drays to the company's depot, where it is put into small glass cans, or jars, for retail trade, and teams are dispatched to the grocers in all of the city and suburban territory. This trade from the Boston office runs as high as 1,800 gallons per day in the hottest summer weather, and will average about 1,000 gallons per day the year round. Incidental to the cream business, about 100 of the usual 8½-quart Boston cans of milk are sold. The milk mostly comes as pasteurized skim milk, and enough cream is added to give it the proper quality. The Maine cream is of two qualities—44 per cent and 17 per cent fat. Some of the cream is sent by railroad to Portland and reshipped on the Portland and Boston boat, which arrives a couple of hours earlier than the train. Such cream as comes by boat is in the usual carriers, and these are packed in broken ice in wooden boxes, which are made large enough to hold a can each.

OFFICIAL INSPECTION AND REGULATIONS.

An unusual amount of attention is paid to the sanitary side of the Boston milk supply. The Massachusetts Board of Health is making an inspection of the dairies supplying the city with milk. A competent veterinarian is employed to take charge of this work. The fol-

lowing shows the form of blank used for reports and the particular matters which he investigates:

COMMONWEALTH OF MASSACHUSETTS.

STATE BOARD OF HEALTH.

Inspection of dairies.

City or town ——— ———. Date ——, 190—.
Name of owner ——— ———. Time of visit —— m.
Number of cows ———. Number of cow stables ———.
Condition of cows (1) as to health ——— (if any are sick, note same on reverse side of blank); (2) as to cleanliness.

Condition of cow stables:
Construction ———. Approximate cubic space per cow ———.
Means of ventilation ———. Condition as to light ———.
Nature of floor of cow stalls ———. Means of drainage ———.
Are the cows bedded? ———. If so, with what? ———.
Where is manure stored? ———. How often removed? ———.
Is hay stored where cows are kept? ———. Are horses kept in same stable? ———.
General condition as to cleanliness ———.

Water supply:
Source of supply (a) for watering stock ———; (b) for washing cans, etc. ———.
Distance of latter from (a) stable ———; (b) possible source of pollution ———.
Direction of ground level from each such source ———.

Milk:
Are the udders cleaned before milking? ———. If so, how? ———.
How is the milk cooled? ———.
Where is it cooled and handled? ———. Where is it stored? ———.
Where are cans, etc., washed? ———. Where kept during milking? ———.
Has the owner an ice house? ———. Is ice easily obtainable in the vicinity? ———.
How much milk is sold? ———. To whom is it shipped? ———.
How far is it hauled for delivery? ———. At what hours is it hauled? ———.
If delivered at a railway station, how long a time is likely to elapse before it is taken into the car? ———.

Signature: ——— ———,
Inspector.

[Reverse side.]

Memoranda as to diseased cows.

Name or number of cow.	Condition.

Remarks:

Not only is the State board of health making investigations, but the city board also does inspection work, particularly along bacteriological lines.

On April 29, 1904, the following regulation in regard to the milk supply was adopted by the Boston board of health:

No person by himself or by his servant or agent, or as the servant or agent of any other person, firm, or corporation, shall bring into the city of Boston for the purpose of sale, exchange, or delivery, or sell, exchange, or deliver, any milk, skimmed milk, or cream which contains more than 500,000 bacteria per cubic centimeter, or which has a temperature higher than 50° F.

During June, July, August, and September 2,394 samples were taken and tested. Most of these were taken from the milk as it arrived in the city. The results were as follows:

	Per cent.
Between 30° and 40° F	4.00
Between 40° and 50° F	49.25
Between 50° and 60° F	39.50
Between 60° and 70° F	7.25
	100.00
Below 50° F. (the standard for temperature)	53.25
Above 50° F. (the standard for temperature)	46.75
	100.00
Below 10,000 bacteria per cubic centimeter	42.50
Between 100,000 and 500,000	29.25
Between 500,000 and 1,000,000	9.75
Between 1,000,000 and 5,000,000	12.75
Above 5,000,000	5.00
Uncountable	.75
	100.00
Below 500,000 (the maximum allowed)	71.75
Above 500,000 (the maximum allowed)	27.50
	99.25

During the first season of this work the board sent out about four hundred warnings where the milk varied from the standard. In many instances good results were quickly noticeable.

PART II.—THE MILK SUPPLY OF NEW YORK CITY.

EXPLANATION OF TERMS.

"Greater New York" is now by law one municipality; hence when the expression "New York" is used it means Greater New York.

The New York milk supply is handled to a large extent in 40-quart cans; therefore the word "can" in connection with the New York milk business means 40 quarts. The milk is hauled by the farmers to milk stations near the railroad stations from which it is shipped, and these shipping stations are locally known as creameries; hence the word "creamery," in connection with the milk supply of New York City, does not mean a butter factory, as in other places, but a place where milk is received from the farmers and prepared for transportation to the city.

MAGNITUDE OF THE BUSINESS.

New York City, with three and a half million people credited to it by the census (1900), and with a large transient population such as every metropolis attracts, consumes daily an immense amount of milk. To estimate the magnitude of the business presents some difficulties peculiar to local conditions. For example, one of the largest firms supplying the city with milk is also one of the largest condensers of milk in the country, and it is very conservative about making reports relative to its business; and so far as reports are made to the State agricultural department of milk received in the country, the figures represent milk received by it for condensing as well as for sale as whole milk. Further than this, the cream business of New York City is largely in the same hands as the milk business, and some official reports refer to the amount of "milk and cream" shipped, whereas, to get at the magnitude of the milk industry alone, we must put the cream on the basis of milk.

Let the question be considered from the theoretical standpoint: Averaging many reports and estimates, we find that the average consumption of milk exceeds half a pint per capita per day. This figure indicates the daily consumption of three and a half million people to be 875,000 quarts of milk, not including cream. Should we add one-tenth of a pint per day (allowance for cream) to the usual daily milk consumption per capita and use six-tenths of a pint as a

multiplier, the product would be 1,050,000 quarts per day. These estimates are based on the ruling daily consumption of milk and cream in smaller places, which have not the large transient population of New York.

Taking the best statistics which we can find, we note that Bulletin No. 25, Division of Statistics, United States Department of Agriculture (p. 13) estimates the New York "milk and cream" supply at 400,000,000 quarts per year, which is 1,093,162 quarts per day. The same bulletin (p. 22) quotes the compilation of a railroad freight agent, who figures up the receipts of milk and cream for 1902 as 428,000,000 quarts. This would be 1,175,300 quarts per day. The State department of agriculture in Bulletin No. 6 (p. 2) reports the amount of milk shipped from stations in the State for the year 1902 as 383,000,000 quarts, with an additional 15,000,000 quarts of cream, these shipments thus aggregating 398,000,000 quarts of milk and cream per year, or 1,087,670 quarts per day. These figures from the State report should be reduced by the amounts shipped to other places than New York City and increased by the amount sent from outside of the State to the metropolis. The New York City department of health, in its report for 1902 (p. 144), states: "The amount of milk consumed in New York [City] is somewhat less than a million and a half quarts daily." Health Commissioner Darlington estimates the consumption of milk in January, 1905, at 1,388,000 quarts daily, as follows:

Manhattan	800,000
Brooklyn	400,000
Bronx	90,000
Queens	80,000
Richmond	18,000

There are no great discrepancies between these various estimates and reports. It is safe to infer that if the cream consumed were put on the basis of milk the industry would be shown to amount to over 1,500,000 quarts daily. If the cows which produce this supply of milk average 7½ quarts daily, over 200,000 cows would be required.

WHERE THE MILK COMES FROM.

Health Commissioner Darlington estimates that 87 per cent of the milk and cream consumed in New York City is produced in the State of New York. This milk comes from distances varying from 40 to 400 miles. The balance of the supply comes from northern New Jersey, northeastern Pennsylvania, western Connecticut, and southwestern Massachusetts.

In regard to the 87 per cent of milk from the State, this may be said as to its origin: The New York City health department esti-

mates that 400 creameries ship milk to the city. The previously mentioned bulletin of the State department of agriculture lists 539 milk stations in the State. This list includes those shipping milk to other cities, but does not include those out of the State which send milk to New York. But an analysis of the location of the 539 milk stations in the State will indicate the relative milk-shipping importance of different counties. The following table gives the number of shipping stations in the thirteen leading counties, as well as their relative rank:

Rank.	County.	Stations.	Rank.	County.	Stations.
1	Orange	71	7	Sullivan	24
2	Delaware	52	8	Broome	20
3	Madison	40	9	Cayuga	17
4	Chenango	30	9	Herkimer	17
5	Dutchess	27	10	Tioga	16
5	Oneida	27	10	Chemung	16
6	Cortland	25			

The following table gives the relative order of the leading counties, based on the amount of milk reported as received at the shipping stations, or creameries, in the counties:

Rank.	County.	Cans received.
1	Orange	86,000,000
2	Delaware	67,000,000
3	Madison	44,000,000
4	Chenango	43,000,000
4	Dutchess	43,000,000
5	Cortland	30,000,000
6	Herkimer	21,000,000
6	Oneida	21,000,000

Both standards agree in placing Orange County first, Delaware second, Madison third, Chenango fourth, and Dutchess fifth. Beyond these the two standards show some variation.

LARGE DEALERS.

Most of the milk sold in New York City is distributed and retailed by dealers who own the shipping stations in the country, and who are therefore receivers, wholesalers, and retailers, all in one concern. Some tables follow which give some idea of the amount of business done by some of the largest dealers. These tables have been prepared by analyzing and classifying reports of the State department of agriculture. The first column relates to the number of shipping

stations; the second column gives the number of quarts received at each of the stations in 1902:

Number of shipping stations.	Number of quarts.	Number of shipping stations.	Number of quarts.
1	14,000,000	5	5,000,000
3	10,000,000	3	4,000,000
1	9,000,000	10	3,000,000
1	8,000,000	21	2,000,000
1	7,000,000	122	1,000,000
1	6,000,000		

The following table shows the number of stations owned by some of the largest dealers, using letters instead of names:

Corporation.	Number of shipping stations.	Corporation.	Number of shipping stations.
A	27	F	8
B	26	G	5
C	25	H	5
D	23	I	8
E	10	J	6

These ten concerns have 143 stations—or one-quarter of the whole number; besides, there are two establishments with 4 stations each, six with 3 stations each, and eight with 2 stations each. There are some difficulties in getting at all the figures, but from the best estimates we can make it appears that five of the largest concerns handle one-third of all the business.

COMMENTS OF DEALERS AND PRODUCERS.

One of the largest dealers said: "There is a growing sentiment in favor of the large corporations, because the larger they become the more reputation and capital they have at stake, and hence the more reason for being reliable." Another dealer said: "The tendency is toward concentration; the small shipper is a thing of the past." A large producer stated: "The day of small peddlers who buy direct of the producers has gone by." One who is good authority made this statement: "The milk business appears to be getting into fewer hands. Probably 80 to 90 per cent of the milk sold in Greater New York is handled by 125 dealers."

MILK ON THE FARMS.

Several influences operate to increase the care with which milk is produced. In the first place, a premium is paid for superior milk in

many instances. Milk produced from healthy cattle under approved sanitary conditions is certified to by an association of physicians, and certified milk commands an extra price. It is produced in airy, well-ventilated barns. The milk as soon as drawn is at once removed and cooled to 38° F. and in that condition sent to market. Such milk never exceeds 5,000 bacteria per cubic centimeter, and frequently it runs as low as 1,500. In the next place, the concentration of the business in large and strong hands tends to raise the quality of the milk, and these corporations frequently have a reputation among the producers of being exacting and arbitrary. If these large concerns are particular as to the care of the milk at the dairy, they not only directly influence the quality of the milk which they receive, but they set the pace, as it were, for other dealers to follow. The largest firm supplying the city market happens to be the most particular, as much of its supply is condensed. The regulations of this corporation go so far as to prohibit the use of foods some of which have the sanction of the best dairy authorities. The list of prohibited foods for cows producing milk for this corporation is: Turnips, barley sprouts, brewery or distillery grains, linseed meal, glucose refuse, starch refuse, buffalo feed, ensilage, rancid oil cake, and gluten meal. Other rules of this corporation which are of unquestionable benefit to the milk supply provide for thorough lighting and ventilation of stables, and whitewashing once a year, together with much care as to cleanliness. The milk room must be separate from the stable, and the entrance to it can not be through a partition or door opening directly from the stable; the milk must be cooled to 58° F. or lower within forty-five minutes; any representative of the corporation shall have the right to inspect any of the stables in which milk is produced for it; night's and morning's milk must be kept separate.

None of the other dealers go so far as the above. One large corporation which does a large business in milk of superior quality has no rules at all, at least no arbitrary list of "thou-shalt-nots," but it merely requires that the milk it buys shall be as good as the best or as good as modern skill can produce. If the milk meets the demands of the purchaser, no questions are asked as to details of production or whether this or that food was fed. This corporation proceeds on the theory that to produce the results which it requires everything must be about right.

Besides the precautions of dealers to secure clean, good milk, health officers are continually on the alert to detect the more flagrant violations of the ordinary rules of care and cleanliness. When the well is found too near the stable, when the surroundings are dirty, or when the cows are kept in dark filthy stables, there is official action.

In some of the milk-producing sections 40 to 50 cows are regarded as an average dairy herd, though in some instances there are as many

as 100 cows in a herd. In other sections from 20 to 25 cows are considered an average herd. Few who live any considerable distance from a creamery produce less than one can of milk per day. The farmers for the most part live within 5 or 6 miles of the creamery and deliver the milk in the morning. This necessitates artificial cooling of the night's milk, which is done in spring-houses or in tanks of ice water. The use of ice is increasing, and in some portions of the territory the gathering of the ice crop in winter is considered almost as important a task as the gathering of the hay crop in the summer. If the night's milk is not below 60° F. when delivered in the morning, it may be rejected. The cooling of the morning's milk depends on the distance the farmer lives from the station. One large dealer has a sliding scale of temperatures for milk delivered, as follows:

	°F.
Night's milk delivered the next morning	50
Morning's milk produced within 1 mile of station and delivered before 7 a. m	60
Morning's milk produced within 2 miles of the station and delivered before 8 a. m	55
Morning's milk delivered after 9 a. m	52

Usually the milk is delivered by 9 o'clock, though there is some difference in time at different stations, depending on the time the milk train leaves. As one stands near a shipping station in the morning he will see every conceivable kind of vehicle drive up to the station door. Some have one horse, others have two, and still others four. As a rule, the wagons have no particular facilities for keeping the milk cool in the summer, except a canvas thrown over the load. The farmers usually own the cans used in the delivery of their milk. When the cans are emptied at the creamery they are rinsed, washed, and then scalded with steam, thus rendering them sterile. In a few minutes after the farmer reaches the station with his milk it has been unloaded and clean cans returned to him.

In some localities the farmers live as far as 12 miles from the creamery, and in such cases there is a different system of getting the milk to the central depot. A collector has a specially built wagon which will carry 40 cans. These collectors are nominally employed by the farmers, but ordinarily the amount due them is deducted from the farmer's check at the creamery, where the collector gets his payment. The usual price for collecting milk is about 10 cents per hundred pounds, the amount varying somewhat according to distance and local conditions. Just before the collector is due in the morning the farmer takes the milk from the cooling tank and places the cans on a little roadside platform, from which the collector takes them. Sometimes the farmer does not live on a road over which the collector passes. In such case the producer meets the collector at the

junction of the roads. When milk is transported long distances in wagons, there are facilities for refrigeration, and sometimes the milk is also iced en route. Some of the contracts with the buyers require the use of wagons with springs in transporting the milk to the creamery.

SHIPPING STATIONS OR CREAMERIES.

DESCRIPTION.

At each point from which milk is shipped to the city there is a building, sometimes known as a shipping station, but more frequently as a creamery. Here the milk is received from the farmers and prepared for shipment. Practically no milk is loaded directly from the producer's wagon into the milk car. These stations are located more or less closely together, according to the amount of dairying in the vicinity. In Orange County, the town of Warwick has 12 stations. In Delaware County, Stamford has 10 stations. Towns with 4 to 6 stations are frequent. On several lines of railroad the stations are at least within 5 miles of each other, and stations 2 or 3 miles apart are not uncommon. Most of the stations are owned by the city dealers, but a few are cooperative or have independent owners. Where the stations are near together they are usually owned by different dealers, and there is sometimes a little competition for the product of the neighboring dairies which can ship to one as well as to the other.

These stations vary greatly as to equipment. The most ordinary have merely a tank for ice water and cans, with a small boiler to produce hot water or steam for washing cans and other utensils. The more elaborate establishments are equipped with clarifier, pasteurizer, bottling machine, bottle washer, separator, churn, cream vat, sterilizing plant, ice crusher, condensery, and, in some instances, repair shop for mending cans and bottle boxes. In every case there is an ice house either attached to the creamery or located very near. Usually a railroad side track runs close to the building for convenience in loading. In some instances a dwelling house is connected with the creamery.

The variation in quality of the equipment in the creameries is very great. In some of the poorer creameries the tanks and floors are of wood; and even where the attendant is very careful the water-soaked and partially decayed wood offers a condition far from ideal; and where there is considerable carelessness in spilling milk and no pains is taken to clear up the neglected corners the condition becomes very bad. The board of health has found the conditions in some cases so bad that it has revoked the corporation's permit to sell milk in New York City. At the other extreme are the creameries of the

large corporations with a fancy trade and plenty of capital. Here we find cement floors, tile walls, and everything bright and shining. Utensils, vats, and tanks are sterilized with live steam, machinery is thoroughly cleaned, while plenty of water is conveyed in hose to floors and walls. The floors are slightly concave, so that the water quickly drains off and they soon become dry.

HANDLING MILK AT THE STATIONS.

In the simplest of these stations the milk is received from the farmer, emptied from his cans, and mixed and cooled for sending to the city in the 40-quart cans. The cans of milk are set in tanks, which are usually so placed that the top is level with the floor in order to save lifting. The cans are placed in ice water and the milk is occasionally stirred, so that it will cool evenly throughout. The stirring is done with a flat disk several inches in diameter, to which a handle is attached at right angles with the disk. Raising and lowering the disk thoroughly stirs the milk.

In the more pretentious creameries milk is clarified, pasteurized, or blended, according to the kind of business done. The bottled milk of the city is largely put up at these creameries. Several of them are also condensing establishments. Many of them put up pot cheese, and the large city demand for buttermilk is met by churning skim milk. The surplus is regulated at the creamery as much as possible rather than in the city. Supplies are ordered from day to day by telegraph at the latest moment possible. Any surplus is left at the creamery to be worked up into butter or to be condensed. Many of these creameries have separators, by means of which the dealers' supply of cream is secured. The State has a low fat standard for milk (3 per cent), and many producers feel that sometimes whole milk is partially skimmed so that a dealer can get quite a cream supply by bringing his milk supply down to a 3 per cent basis.

The higher the standing of the dealer the better the condition of his creamery. Dealers who sell to others to sell again have a minimum of responsibility, and the condition of the places belonging to them does not average so good.

It is estimated by Darlington that about one-third of the city milk supply is sold in bottles. Most of this is bottled in these creameries. The remainder—the two-thirds—is shipped to the city in cans to supply the large customers, like hotels, restaurants, institutions, and grocers, also a few peddlers.

These shipping stations are not only subject to the inspection of the city board of health, which can refuse permits to city dealers if the country conditions are not all right, but the State agricultural

department has direct supervision of them and can make suggestions as to changes.

The empty cans come back from the city dirty, and are washed at these creameries. When the cans have stood some time in a grocery store or near a kitchen fire their condition is bad, and this negligence is criticised by health authorities. But there is every facility at the creamery for giving them a thorough cleansing.

CARS USED FOR TRANSPORTING MILK.

The cars used in transporting milk to New York City are practically the same over the whole of the territory. The only differences are in size and minor details. In external appearance they are like ordinary express cars, with one central door on each side. In a few instances there are end doors. The word "Milk" is painted on each side of the car, with the name of the railroad corporation. The entire space inside the car is in one compartment. Having no partitions, the cars can easily be kept clean by flushing with water. This is usually done daily in summer. The construction of the cars is similar to that of the familiar refrigerator cars. The walls are double, and there is a trap door in the roof for loading ice, with ventilating openings in the sides near the bottom. Most of the cars are piped for steam so that the milk can be kept from freezing in the winter. These cars are all of the time under the direct control of the railroads. The railroad company therefore assumes the responsibility for the care of the milk en route, and takes entire charge of the refrigeration in the summer. For this purpose it has icing stations on long runs, where the cars are iced, either at the top or by placing cakes of ice among the milk cans.

Where the shipping station is a large one, a car is placed on the railroad siding near the building, and the men employed about the creamery load the cans or boxes of bottles. When the milk train arrives, all that is necessary is to back onto the siding and connect with the car. In the case of small creameries the milk is loaded while the train waits. Sometimes the work is merely twirling the cans across a gangway into the car door. In other cases the trainmen have to carry the cans or boxes across a track. Sometimes, when the station stands back from the railroad track, there is a loading platform near the track, connected with the creamery by a bridge, and the manager has the cans on the loading platform before the train arrives, which greatly facilitates the work.

DESCRIPTION OF A MILK ROUTE.

The following details of a trip on a milk train from Binghamton

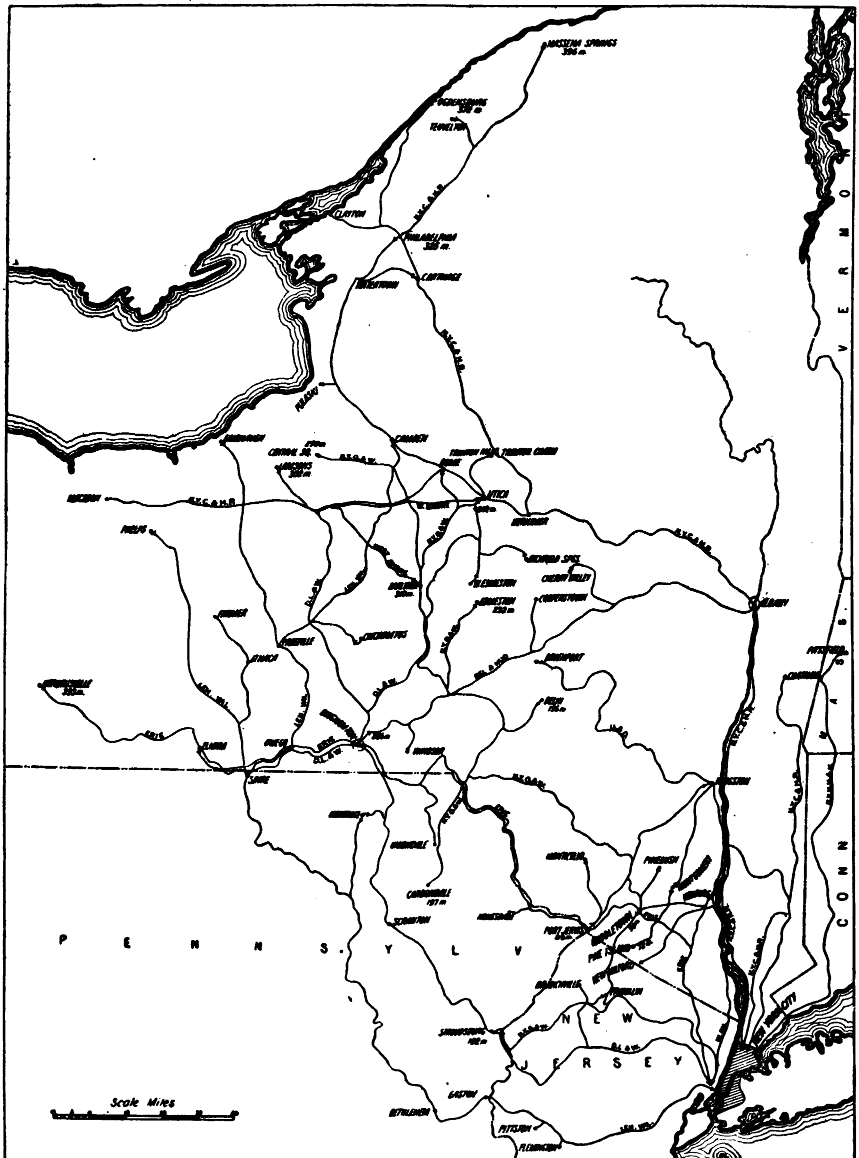

FIG. 3.—Map showing the source of New York's milk supply.

to Albany will not only describe that particular route, but, so far as it is typical, will throw light on the general methods practiced:

The train leaves Binghamton at 9.15 a. m. with three empty milk cars and two passenger coaches. The few passengers are for local

points not far distant from Binghamton. Eleven miles out the first milk is taken, 40 cans being loaded from a rather dingy looking creamery. After a ride of 4 miles a stop is made at a station where 13 cases of bottled milk are loaded. After 3 miles more, we come to a station where there is a creamery which utilizes all the milk locally. Three miles farther on about 100 cases of bottled milk are taken on. A mile beyond, at Nineveh Junction, a whole car which has come down a branch road is attached to the train. Afton, 5 miles beyond, is reached at 10.20, and at this place between 60 and 70 cans are loaded. Six miles more brings us to Bainbridge, where another car is coupled to the train, near a bright, white creamery. Some of the milk for this creamery is hauled from farms 8 and 10 miles distant. As we get farther down the grade the valley broadens, and many thrifty farms are seen. Nine miles farther yet, after being on the road two hours, two cars are picked up; 5 miles more and another car is taken, and after 4 miles still another. At this last station nearly two carloads are shipped, so that there is a considerable amount to be loaded by the trainmen. At Oneonta a car is added, and 6 miles beyond something like 100 cases of bottles are loaded. The next five stations are from 3 to 5 miles apart, and at each one of these a considerable quantity of milk is loaded, in one case 105 cans. Cobleskill is reached about 3 p. m., where a car is coupled to the train, which waits for all the cars to be iced; this is done by placing a cake of ice in the space between groups of four cans each. A few more small lots of milk are loaded at different stations. Albany, 143 miles from Binghamton, is reached at 4.40 p. m., seven hours and twenty-five minutes from the start. Here the cars brought in over the several roads are made up into a long train, and at 8.20 the train is rushing at high speed to New York City.

The loading of the milk on this train is done by the trainmen, and the record of the shipments is kept by the conductor, just as the conductor of an ordinary freight train keeps record of the numbers on the cars, waybills, etc.

FREIGHT RATES.

Freight rates on milk to New York City are based on a zone system recommended by the Interstate Commerce Commission, and are as follows on 40-quart cans:

	Cents per can.
Up to 40 miles	23
Between 40 and 100 miles	26
Between 100 and 200 miles	29
200 miles and over	32

This system of rates is followed by all of the roads, the only apparent difference being in the case of the New York Central Railway, which makes one rate for a whole division for those dealers on the east

side of the Hudson River. These division rates have a relation to the rates of the foregoing table, being near to the rate of the zone in which the most distant point of the division is located. This system of the Central Railway makes it possible for a shipper on one division to pay more than one on another division living the same distance from the city.

The railroads seem to be in substantial agreement as to the freight on cream, which, with but few exceptions, is 18 cents per can more than the freight on milk. The transportation costs no more, but the extra charge is justified on the principle defended by many economists, that the cost of an article, or its value, is a proper element to consider in fixing the freight charge.

The freight charges on bottled milk and cream are less uniform than on the same commodities in bulk. The tendency of the railroads is to advance the rate on the bottled goods. In several instances there has been an advance in these rates since the publication of Bulletin No. 25 of the Division of Statistics (1902). The published rates of the railroad companies do not have any common unit. For instance, some quote rates by the case, which may contain quarts or pints, or anywhere from 10 to 24 bottles to the case. In the following table the computation has been made on the basis of the quart; when the milk or cream is put up in quart bottles, 12 to the case are understood:

Freight rates on milk and cream carried into New York City.

Zone.	Railroad.	40-quart cans.		Quart bottles.	
		Milk.	Cream.	Milk.	Cream.
		Cents.	*Cents.*	*Cents.*	*Cents.*
First zone	Erie	23	41	0.80	1.43
	West Shore	23	41	.77	1.22
	D., L. & W	23	41	.81	1.43
	Lehigh Valley	23	36	.83	
Second zone	Erie	26	44	.91	1.54
	West Shore	26	44	.85	1.30
	D., L. & W	26	44	.91	1.54
	N. Y., O. & W	26	44	.91	1.54
	Lehigh Valley	25	36	.83	
	N. Y., N. H. & H	25	30	.87	1.05
Third zone	Erie	29	47	1.01	1.64
	West Shore	29	47	.92	1.37
	D., L. & W	29	47	1.00	1.64
	N. Y., O. & W	29	47	1.01	1.64
	N. Y. C., main line	29	47	1.02	1.64
Fourth zone	Erie	32	50	1.12	1.75
	West Shore	32	50	1.00	1.45
	D., L. & W	32	50	1.11	1.75
	N. Y., O. & W	32	50	1.12	1.75
	Lehigh Valley	32	50	1.12	1.75
	N. Y. C	32	50	1.12	1.75
	N. Y. C., R. W. & O. Div			1.45	

Freight rates on milk and cream carried into New York City—Continued.

Zone.	Railroad.	40-quart cans.		Quart bottles.	
		Milk.	Cream.	Milk.	Cream.
		Cents.	*Cents.*	*Cents.*	*Cents.*
New York Central (divisions east of Hudson River).	Putnam division (most remote point 54 miles.)	25	30	.87	1.05
	Harlem division (most remote point 127 miles).	25	35	.87	1.22
	Hudson division (most remote point 148 miles).	30	40	1.05	1.40

Taking the 26-cent zone for illustration, it will be seen that the rate per quart when the milk is in cans is 0.65 cent; when it is in glass bottles, packed in substantial wooden cases filled with crushed ice, the rate is about 0.9 cent. The ratio of actual weight is about 2½ to 1.

Most of the roads allow a discount of 20 per cent from the above rates for carload lots; hence the definition of a carload is of concern. The common case, containing a dozen quart bottles, when iced weighs 85 pounds, and 600 of these ordinarily constitute a carload. This is 7,200 quarts, or 51,000 pounds, although the weight is constantly lessening as the ice melts. The New York, Ontario and Western Railroad states that for the purpose of its freight tariff a carload must consist of at least 250 cans, or 7,000 quarts in bottles. This would be 10,000 quarts in cans, or 7,000 in bottles. The Delaware, Lackawanna and Western Railroad defines a carload as consisting of 9,000 quarts in cans, or 6,500 quarts in bottles.

MILK TRAINS.

HOW RUN, TIME, DISTANCE, ETC.

The milk cars are usually run in milk trains entirely distinct from the passenger service. In some instances, however, a passenger car is attached to a milk train during the portion of its run in which it is picking up the load of milk. In other instances, on some branch roads, the milk car is attached to a regular passenger train, or even to a freight train, the milk cars being made into a milk train at the junction. Exclusive milk trains are run on the fastest time of any trains on the road, and are drawn by the strongest and surest locomotives.

The prevailing manner of distributing milk in the city calls for the arrival of the trains in the night, generally between 10 o'clock and midnight. We have prepared a table showing the time the milk cars or trains leave some of the most remote points, the distance

traveled, and the time on the road. It is worthy of note that these trains pick up milk for long distances, and that milk produced near by reaches the city no sooner than that produced 300 miles away. The morning's milk always reaches the city before midnight, but there are places where the trains stop to take on fresh milk as late as from 2 to 6 o'clock in the afternoon.

Table showing time milk trains leave, distance traveled, and time on road.

Railroad.	Starting point.	Distance.	Time leaves.	Time arrives.	Time on road.
		Miles.	*a. m.*	*p. m.*	*h. m.*
N. Y., O. & W	Sidney, N. Y	201	10.35	10.10	11 35
	Central Square, N. Y	300	7.25	10.50	15 25
D., L. & W	Elmira, N. Y	264	8.40	9.33	12 53
	Syracuse, N. Y	287	9.05	10.22	13 17
	Utica, N. Y	302	9.30	10.36	13 6
	Richfield Springs	311	9.10	10.36	13 26
			p. m.		
N. Y., N. H. & H	Pittsfield, Mass	155	12.10	10.12	10 2
			a. m.		
Erie	Hornellsville, N. Y	332	8.07	10.15	14 8
			p. m.		
	Port Jervis	89	4.50		
	Pine Island	72	4 25		
			a. m.		
Lehigh Valley	Clockville	387	8.04	10.30	14 26
N. Y. Central	Massena Springs	396	7.00	11.00	16 0
	Ogdensburg	372	11.00		
			p. m.		
N. Y., Sus. & W	Middletown, N. Y	90	3.10	10.30	7 20
	Stroudsburg, Pa	102	2.46	10.30	7 44

ARRIVAL IN THE CITY.

The milk trains arrive in New York City about the same time—from 10 to 11 o'clock at night. There are, however, several places of arrival—at Harlem River (One hundred and thirtieth street), at Highbridge, at Thirtieth street and Tenth avenue; but the great mass of the milk is delivered in New Jersey.

At the railroad terminals there are no special arrangements for the milk business aside from the covered platform to be found at all freight stations. The different dealers are on hand on the arrival of the trains to get their several supplies. There is no confusion, principally for the reason that there is not a large number of small dealers to complicate the delivery. Transportation from the railroads is done chiefly by large wagons drawn by three or four horses.

HANDLING MILK IN THE CITY.

When the large wagons leave the railroad stations they are driven to the headquarters of the different large dealers, where the load is

transferred to smaller wagons for distribution throughout the city. The city milk station is chiefly a combination of a counting room and a stable, the office being on the second floor, the first floor being devoted to space for wagons. Some of these places have a small refrigerator for keeping a little surplus milk, and occasionally there is a churn and other facilities for making butter of inferior quality from sour or surplus milk. In two or three instances large dealers have fitted up rooms for pasteurizing and bottling milk in the city. Where these large dealers retail milk from a store it is entirely separated from the main place of business.

Speaking in a general way, about one-third of the city supply is delivered in bottles and two-thirds in cans. The "can" milk goes to institutions, hotels, restaurants, and grocery stores. There are 7,000 such stores in the Borough of Manhattan.

HOW THE PRICE IS DETERMINED.

Three ways are in vogue for determining the price to be paid the producers. The first is by the New York Milk Exchange. This is an organization, nominally of representative producers and dealers, for the purpose of studying the situation from the standpoint of each and fixing a price, after a canvass of the supply, demand, and cost of production. The exchange has 17 directors, who determine the price of milk when conditions seem to warrant a change from the prevailing price. Sometimes the price is changed three times a month, although so frequent changes are not common. No definite advance contracts or prices are made by the exchange. The price fixed upon to-day is the price until another is determined upon. Of the seventeen directors, the secretary reports that more than one-third are producers. One of the largest dealers stated that two of the directors were farmers, while others are both producers and shippers. But the mass of the producers resent the claim that they have any representation in fixing the price. About three-fourths of the New York milk is bought on the exchange basis. The net price to the farmers is the exchange price, less three items—the zone freight rate, 5 cents per can as a ferriage charge on such milk as is landed in New Jersey, and a "station charge" of 10 cents per can. The exchange price in February, 1905, was $1.61 per can. In the second zone there would be deducted 26 cents freight, 5 cents ferriage, and 10 cents station charge. This would make the net price to the farmer $1.20, or 3 cents per quart. The station charge varies somewhat with the competition between different shippers when their creameries are located near each other.

Much milk which is paid for on the exchange basis is actually bought by the 100 pounds. The milk is weighed when delivered

by the farmer at the shipping station and then reduced to cans at 86 pounds to the can. In handling milk in large quantities the use of the words " can " and " quart " as units in price making seems to be decreasing and the system of paying by the 100 pounds is increasing.

The second way of paying for milk is that adopted by the largest purchasers, who buy for condensing as well as for direct sale, and who condense much of their surplus in seasons when there is an abundant production. These purchasers buy by the 100 pounds, but make a price for a period of six months in advance. It is claimed that the exchange price is influential as a basis in fixing this scale of prices, although the two do not always agree. The price paid per 100 pounds is a net price at the shipping station, " condensery," or creamery.

The third way of buying is by the 100 pounds on the basis of the fat in the milk. Samples are taken daily and tested. The agreed price is for milk testing 4.2 per cent, and 2 cents additional is paid for each one-tenth of 1 per cent of fat.

MILK SANITATION.

In handling an article as susceptible to contamination and deterioration as milk, the question of sanitation is important. The problem is also difficult, for it must deal with the thousands of producers, then with the conditions at the shipping stations, next with the manner of transportation, and finally with the manner of retailing in the city. Many of the smaller groceries have no facilities for keeping milk cool in the summer, and they give the city board of health much trouble. In one section it is stated that, " out of a total of 2,458 stores visited, only 454 were found where the milk was properly cooled and where there was no communication with living rooms."

The State agricultural department has direct supervision over the sanitary conditions in the country, especially at the shipping stations. Where the places are in bad condition, the department can require them to be cleaned up. The city board of health makes occasional investigations of the country conditions, and if they are insanitary the board refuses permits to sell milk in the city from such places. In this way a local board of officers can indirectly exercise supervision over matters beyond its jurisdiction.

PART III.—THE MILK SUPPLY OF PHILADELPHIA.

AMOUNT—SOURCES—CARS.

The milk supply of Philadelphia for the year 1903 was 111,242,000 quarts. This was received from the following sources:

		Quarts.
Pennsylvania Railroad		47,984,000
Reading Railroad:		
Near by	35,354,000	
Distant	3,488,000	
		38,842,000
Baltimore and Ohio Railroad		7,015,000
Lehigh Valley Railroad		10,201,000
Wagons (estimated)		7,200,000
Total		111,242,000

For six years the annual rate of increase has varied from 1,000,000 to 6,000,000 quarts and averaged nearly 3,000,000 quarts, rising from 93,959,000 to 111,242,000.

Stating the receipts for 1903 by percentages and rearranging the order of the above table, we have the following results:

		Per cent.
Pennsylvania Railroad		43.2
Reading Railroad (near by)		31.5
Baltimore and Ohio Railroad		6.3
Total near-by railroad milk		81.0
Wagon milk		6.3
Total near-by milk		87.3
Lehigh Valley Railroad	9.0	
Reading Railroad (distant)	3.6	
		12.6
Total		99.9

From the above table it will be seen that 87 per cent of the city's milk supply comes from comparatively near-by sources, chiefly in Pennsylvania and New Jersey, and some in Delaware. About 6 per cent is estimated to be brought into the city in wagons from dairies near the city or situated within the territorial limits of the munici-

pality. Five thousand cows are reported within the city limits. The "wagon milk" is gradually growing less as the value of land near the city increases and becomes less available for dairying. Of the 93 per cent of the city milk which is transported to the city by railroad 81 per cent comes from within 60 miles. This milk is transported in ordinary baggage and express cars. No money is expended in fitting them up for milk cars; in fact, they are not even labeled. The Pennsylvania Railroad cars have two doors on each side, and the Reading Railroad cars have three. Most of the cars are piped for heating. A few have old-fashioned stoves, but none have any facilities for refrigeration. The cars are for the most part clean, but in some instances more attention to cleanliness on the part of the railroad companies would seem desirable. The cars are usually run in connection with passenger trains. In some instances the milk

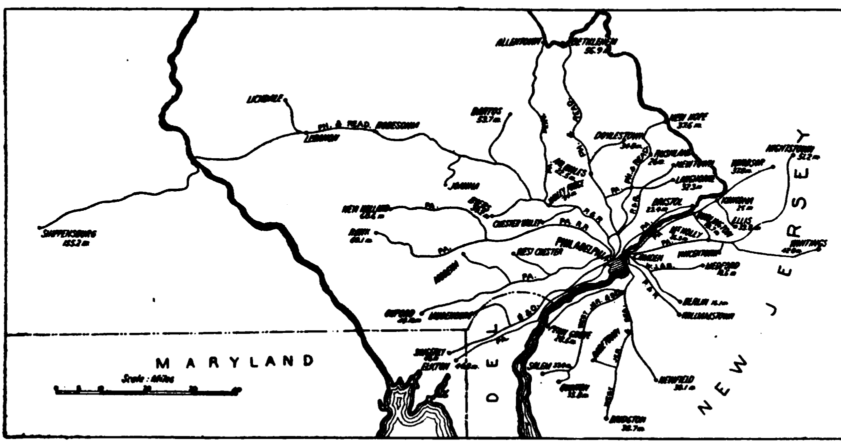

FIG. 4.—Map showing the source of Philadelphia's milk supply.

cars start with passenger trains, but on reaching the junctions they are made up into a special milk train. In such cases there is usually no milk taken on between the junction and the city.

As the milk is transported in baggage cars on passenger trains, the transportation is closely connected with the passenger department of the railroads, and on the Pennsylvania system the business is entirely in charge of the latter department.

THE CANS.

Fully 90 per cent of the cans used in the business are owned by the farmers. Forty-quart cans are used for the most part, although there are some "30's" and a few "20's." The cans vary much in shape, some being much taller than others of the same capacity.

Many farmers paint their cans to assist in their preservation. A pile of cans at a large railroad station in Philadelphia presents less uniformity than in Boston or New York, as there are cans of various shapes, sizes, and ages; some are quite rusty and have the paint nearly all worn off. Sometimes the cans are kept in service longer than they should be; the covers especially become battered and otherwise out of repair, and some were found to be in an insanitary condition.

FREIGHT RATES, AND HOW PAID.

The farmers sell their milk, delivered in Philadelphia, at a definite price. Payment for transportation is made by a system of tickets, printed for convenience on common shipping tags. These tags are attached to the cans, which are not supposed to get on the train without tickets any more than are passengers. When the cans are loaded the baggage master goes through the car and takes up the tickets after the manner of the conductor, the difference being that the tickets are taken up by detaching the ticket portion of the tag on a perforated line. The tickets, each good for the transportation of a 20-quart can, are sold in bunches of 20 for $1.50, $2, or $3, depending on whether the milk has to be transferred at a junction. Other tickets are sold for 30-quart and 40-quart cans, although two 20-quart tickets will be taken for transporting a 40-quart can. Any farmer can buy a bunch of tickets and put his milk on any milk car. By this system no special privileges are shown to anyone, and even the smallest producer can ship milk to the city without any inconvenience and on as good terms and conditions as the largest shipper. In local language, rates are sometimes spoken of as a $2 rate or a $3 rate, according to the price of 20 tickets, but in order that the rate may be understood by those in other places it is placed on a 40-quart can basis. Twenty tickets for 20-quart cans sold for $1.50 is at the rate of 7½ cents per can, or 15 cents per 40-quart can. Fifteen cents will pay for transportation of 40 quarts of milk on the Pennsylvania division of the Pennsylvania Railroad from all points less than 60 miles from the city, where the cans are not transferred at junction points; in this case 5 cents extra is charged. The same price is charged on the Philadelphia, Baltimore and Washington division, from all points less than 30 miles; on the United Railroads of New Jersey division, from Bristol, Langhorne (32.3 miles), Burlington, N. J., Mount Holly, N. J. (19.1 miles), and intermediate points; on the West Jersey and Seashore division, from all points (the extremes from which milk is shipped are 38 and 51 miles); on the Baltimore and Ohio, from all points from which milk is shipped, none being over 43 miles; on the Philadelphia and Reading, from points as far out as Newtown (26.3 miles), Rushland (26 miles),

North Wales (22.5 miles), Valley Forge (24 miles); and on the Philadelphia and Reading, over Baltimore and Ohio, less than 80 miles.

Twenty cents will pay for transportation of 40 quarts of milk on the Pennsylvania division of the Pennsylvania Railroad from points within 60 miles where there is a transfer; on the Philadelphia, Baltimore and Washington division, from points between 30 and 50 miles; on the United Railroads of New Jersey division, from all points from which milk is shipped beyond those in 15-cent class above; on the Philadelphia and Reading, from all points from which milk is shipped beyond those in the 15-cent class above (except for long distance as shown below). Twenty-five cents will pay for transportation of 40 quarts of milk on the Philadelphia, Baltimore and Washington division of the Pennsylvania Railroad for distances between 50 and 75 miles, but little milk is shipped from these distances. The same statement will apply to shipments between 60 and 90 miles on the Pennsylvania division. The rate is also 25 cents between Hightstown and Lewiston, N. J., but this is a 20-cent rate plus 5 cents for transfer.

The rate for cream is double the rate for milk. Two milk tickets are required on a cream can.

Three and a half million quarts, or about 3.6 per cent of the city supply, comes long distances over the Philadelphia and Reading road. This milk dispatch consists of three or four cars which run on a fast freight without refrigeration facilities. The milk is waybilled the same as other freight, and the rates are: On milk from Lebanon Valley and Shippensburg, respectively, for 20 quarts, 20 and 21 cents; for 40 quarts, 30 and 32 cents; on cream, 20 quarts, 30 and 32½ cents; 40 quarts, 50 and 55 cents.

Ten million quarts, or about 9 per cent of the supply, is received from New York State from about ten shipping stations. These stations are owned by seven Philadelphia dealers. This milk comes on the Lehigh Valley road with the train for New York City to Bethlehem, where the train is divided, part going to New York and the rest to Philadelphia. The most remote car starts from Fairhaven, on Lake Ontario, 353 miles from Philadelphia. This milk comes in the usual type of New York milk cars, provided with refrigeration facilities in the summer:

TIME OF STARTING—ARRIVAL.

The near-by railroad milk (about 81 per cent of the whole) starts from the country at the terminal points of the several branches or divisions from 5.30 to 6.30 o'clock in the morning and arrives at the milk stations in the city at from 7 to 9 o'clock, much of it being on the

road only two hours, and some even less. This short run accounts for the lack of special cars and refrigerating facilities. The shippers and railroads claim that if the milk is properly cooled by the producer and then promptly put on ice by the dealer in the city it can not suffer deterioration during the short time it is in transportation.

The long-distance railroad milk reaches the city about midnight. The Philadelphia and Reading train leaves for the city early in the afternoon. The car which starts from Fairhaven, N. Y., leaves at 6.30 in the morning.

The milk which arrives in the forenoon is taken to the milk depots of the dealers for bottling, if to be sold in bottles, and all is put on ice for delivery the next morning. The long-distance milk is taken from the cars for more speedy delivery the same morning. The trains which collect milk from near-by as well as distant stations take both morning milk and milk of the previous evening. Milk produced over 300 miles from the city and that produced within 20 miles is delivered to the consumer at the same time. One large dealer who has both near-by and distant milk claims that the milk coming 200 and 300 miles reaches the city in as good condition as milk produced nearer, for the reason that it has thorough refrigeration in transit, and extra precaution is taken in its production and preparation for transportation.

The milk business in which Philadelphia is concerned has practically no wholesalers; that is, there is practically no milk sold by dealers to be sold again, except in the case of a few grocers. All dealers, except grocers and provision storekeepers who handle milk, buy of the farmers direct and then go to the train for their supplies each forenoon as soon as the train is due. The nearest approach to a middleman is a broker or agent at some stations. Sometimes, if a farmer wants to take up the milk-shipping business and has no customer, he consigns his supply to this broker, who disposes of the product to the best advantage, usually on the platform at the railroad; he has no teams, cans, or storage facilities. When the smaller dealers occasionally want a little extra milk, they can get it of this broker.

THE PHILADELPHIA MILK DEPOTS.

Most of the Philadelphia milk is received at three railroad stations, one across the river in Camden and two in the city. At each of the city stations—Thirty-first and Chestnut streets and Third and Berk streets—there is a long shed with platforms where the milk is unloaded and the cars again filled with empty cans, and where the dealers handle their milk. Wagons of every conceivable style and condition as regards paint and cleanliness can be found standing at the plat-

forms of these stations. The greater part of these have canopy tops. Many are covered with signs and advertisements. The word "Alderney" is popular for advertising milk in Philadelphia.

The scene is decidedly animated at these stations when a train is in. Flitting among the men and cans is an occasional officer of the city health department or an agent of the dealers' association taking samples, the former for the enforcement of the law and the latter for the information and protection of the dealers who cooperate in this work. The inspector has a utensil which stirs the milk by means of a broad flange and takes a sample at the same time.

THE CAMDEN MILK DEPOT.

At Camden, N. J., 28,300,000 quarts of milk were received in 1903. Of this amount, 3,400,000 quarts were for Camden and the remainder for Philadelphia. The statistics relating to Philadelphia are exclusively for the municipality and do not include suburban territory. The freight rate on the New Jersey milk is to Philadelphia, which is reached by ferry across the Delaware River from Camden. The milk is delivered to the dealers at Camden, but they are given free tickets across the ferry, which is controlled by the railroad company. The number of milk teams crossing the ferry in 1903 was 32,297 one-horse, 8,455 two-horse, and 1,331 three-horse or four-horse—a total of 42,083, and a daily average of 115. It will be noticed that the one-horse wagons are in the majority. This also indicates the proportion of small dealers in the business, all of whom buy direct from the farmers. The cars come in mostly on one track, parallel with the tracks in the passenger station, and on one side of the station building. The milk-car track has a shed of its own, the cars running in on one side, while the wagons back up on the other. The shed is 500 feet long, and, during the busiest day of the summer of 1904, 109,900 quarts were handled. The daily number of cars is about 16.

The conditions described at Camden are similar to those at the railway station in the city except that the latter are not so near the passenger depot and the milk cars can not be removed from the passenger trains quite so conveniently.

RECEIVING STATIONS COMPARED WITH THOSE OF BOSTON.

The Boston milk-receiving stations are situated on spur tracks of the railroads, under control by ownership or lease of the milk companies, and they include large buildings, with executive and business offices as well as an abundance of facilities for handling milk at wholesale and retail, including mixers, refrigerators, storage tanks, butter-making outfit, bottling machinery, etc. In some cases the mixing

tank is placed in the car and the milk poured into it and pumped to coolers and refrigerator tanks on an upper floor, thus economizing labor to a great extent.

At Philadelphia the method is quite different. At the railroads there is no outlay for handling milk except the sidetrack with a shed overhead, as in the case of any freight track. Here the cars are switched, each car having milk possibly for a score of different dealers. To these sheds come all the milk peddlers of the city in every conceivable style of vehicle. There is a busy time unloading these cars and sorting out each dealer's milk, getting it on his wagon, and loading into the cars the empty cans. This work is supervised by an official of the railroad, who has a gang of men under him to help in the work. Some of the largest dealers (reported to handle as high as 21,000 quarts per day) are there with their three-horse wagons, which hold 100 40-quart cans each. The small dealer who handles only two cans is also on hand with his small delivery wagon. The Philadelphia system is extremely democratic. The smallest has equal privileges with the largest.

PLACES OF THE DEALERS.

While the Philadelphia system requires that all but the very smallest dealers have a place of business for mixing, bottling, and storing milk, in New York much of the bottled milk for the family trade is bottled in the country, and a dealer can do a large business with no other city facilities than a stable and a counting room, the large loads from the railroads being shifted to the smaller delivery wagons in the stables without opening can or bottle. In Philadelphia, after the dealer has hauled his day's supply from the railroad to his place of business, his day's work is only just commenced. Then begins the mixing, cooling, bottling, icing, and loading for the next morning's delivery. These Philadelphia milk depots, scattered all over the city, present a great variety of conditions and keep the board of health busy with inspections; even then the conditions are far from ideal. There are some large dealers, veterans in the business, who have establishments which are all that could be required, while others are far from perfect.

The writer visited a milk depot fitted up in the basement of a residence. The milk was unloaded from a three-horse wagon onto the sidewalk, from which it was lowered to the basement by a small elevator. In the basement were all the appliances for mixing, bottling, and icing the milk and cream. The basement floor was of cement and well drained, and the premises clean. When the milk had been transferred from the wagon to the cellar, the sidewalk was scrubbed

with soap and hot water. In a rear room was a separator and churn for working up any surplus. The front room on the street floor was fitted up for a retail trade in milk and cream. The other portion of the building was used by the family. Here for the first time the writer saw quarter-pint bottles of cream, which retail for 7 cents, and seem to be in much favor in that locality. Another dealer's place of business occupied an entire building. It was a large establishment fitted with a wide range of machinery—pasteurizer, churn, separator, bottler, bottle washer, and artificial-ice plant; but the place had a dingy appearance, and although the floors were of cement, there was much woodwork which was badly watersoaked and somewhat musty.

CANS IN RELATION TO PRICES.

Comparison of the prices received for milk by producers supplying different markets is difficult because of the varying conditions. For example, the producers supplying the Philadelphia market not only pay the freight directly by a ticket on each can, as explained elsewhere, but also furnish the cans in which the milk is transported to the city. Consequently, to get at the net returns received by the farmers supplying the Philadelphia market the cost of the freight and the wear and tear on the cans must be deducted. In the case of the Boston supply, all cans are furnished by the wholesalers, and in the case of the New York supply the farmers' cans are used only for taking the milk from the farm to the railroad shipping station, being all the time under the personal care of the farmer or his agent. But in the Philadelphia milk supply the farmers' cans are loaded on the cars, go to the city, are hauled from the railroad station to the dealer's place of business, and then go back over the route again. Thus these cans are subjected to destructive wear, and the expense of maintaining cans in a large dairy must be considerable. It is this fact of the individual ownership of cans that leads to less uniformity in size and shape than in other places, and to the use in some instances of cans that are badly worn and quite rusty, while some of the covers are so dilapidated that perfect cleaning is impossible.

There has been some discussion between the producers and dealers as to the return of the cans in a clean condition, and the producers have at times attempted to secure legislation regarding this. The contention of the dealers is that the ordinary rules of business, applicable to all products, require the seller of any product to furnish a suitable package for its transportation. In some instances the dealers rinse the cans before returning them. The writer has seen cans rinsed at the railroad platform, the rinsings from one can being turned into a second, and so on through the whole number in the custody of the dealer.

SHIPPING TAGS.

The shipping tags on the milk cans are all arranged so that the night's and morning's milk may be distinguished. The tag can be divided at a perforated line and the part remaining on the can shows the age of the milk, while the other portion can go to bookkeeper or checking clerk, as desired.

THE PHILADELPHIA MILK EXCHANGE.

The Philadelphia Milk Exchange is an incorporated organization of dealers which handles the greater part of the milk received and sold in the city. These dealers consider matters of mutual interest. Such topics as enforcement of laws, insurance, stray cans, hours of Sunday work, etc., are discussed. Once a month the members meet to consider the price of milk for the coming month. After noting the market conditions, they determine what is a fair price, endeavoring to do justice to all concerned, but looking at matters, of course, from the dealer's standpoint. The price decided upon by the association is then paid to farmers supplying the milk. A representative of the producers' association has met with the exchange on a few occasions to fix the price, but the conference resulted in a failure to agree, and since then the exchange has fixed its own price. There have been some attempts at consolidation of the larger concerns in accordance with the spirit of the times, but they have never succeeded, largely on account of the unpopularity of "trusts."

BOTTLING AND STORING DEPOTS.

As already stated, the milk arrives in the city at 8 to 9.30 in the morning, as a rule, and large customers, who buy by the can, are frequently supplied at once, but most of the milk is carried to the place of business of the dealer, where it is bottled and, in the summer, placed on ice until the next morning. One estimate is that probably 75 per cent of the milk for the family trade is bottled. This milk is delivered at from 3 to 7 o'clock in the morning. On the second trip of the dealers a little "dipped" milk is sold to families who call for extra milk.

With such a large number of dealers of all nationalities and conditions the sanitary conditions in the bottling depots are naturally varied, but the board of health makes a systematic inspection of these places, and where the conditions are too bad and the dealers are persistent in their neglect to make improvements the board puts a stop to the business. The better class of dealers, who have more capital and larger interests at stake and a good reputation to maintain, voluntarily keep their establishments up to a high sanitary state; they consider this necessary to success in their business.

RULES FOR PRODUCERS.

There are no general rules for all the farmers as to the care of the milk. This is largely a personal matter with each dealer. Those who have a fine class of trade for a good quality of milk are compelled to be particular with the producers if they are to hold their trade.

Below are copies of two circulars sent out by dealers to their producers:

Directions for the Care of Milk

Remove the milk of every cow from the dairy at once to a clean, dry room, where the air is pure and sweet. Do not allow cans to remain in the stables while they are being filled. Strain the milk through a metal gauze and a flannel cloth.

AERATE AND COOL THE MILK AS SOON AS STRAINED.

The rapid aeration and cooling of milk are matters of great importance. Combined aerators and coolers, suitable for use with well water or ice water, can be had at any dairy-supply house at a small cost. By using one of these, the cow odor, the animal heat, and much of the dirt can be removed from milk in a few minutes.

The milk should be cooled to 45° if for shipment, or to 60° if for home use or delivery to a factory. Never mix fresh, warm milk with that which has been cooled.

DO NOT ALLOW THE MILK TO FREEZE.

When cans are hauled a distance, they should be full and carried in a spring wagon. In hot weather cover the cans, when moved in a wagon, with a clean wet blanket or canvas.

If milk is stored, it should be held in tanks of fresh cold water, renewing daily in a clean, cold, dry room. Clean all dairy utensils by first thoroughly rinsing them in warm water; then clean inside and out with a brush and hot water in which a cleansing material is dissolved; then rinse, and lastly sterilize by boiling water or steam. Use pure water only.

After cleaning, keep the utensils inverted in pure air and sun, if possible, until wanted for use. Old cans, in which parts of the tin are worn off, or where there are seams and cracks, are impossible to keep clean and should not be employed.

PHILADELPHIA, *May 1, 190–*,

DEAR SIR: We wish to caution you about *grassy milk*, as it is very objectionable to most people and causes much trouble and loss of sale, therefore we urge the utmost care in turning out cattle to grass. The first day they should be allowed to stay out a very short while; then increase the time limit a little each day until the effect wears off and the cow's system becomes used to the change of diet.

Watch for *garlic*, as it entirely spoils milk and cream for sale. Always use an *aerator*, winter and summer, and *ice*, when necessary, so as to get temperature of milk down to *40 or 50 degrees*. See that your *tins* are in good

condition and cleanly. Get the best *strainer* possible, as sediment is very unpleasant in milk.

If you will observe the foregoing rules, many of the evils of the milk business can be corrected.

Very respectfully, ——— ———.

USE OF ICE.

The use of ice is increasing, particularly in the level districts of New Jersey. In the hilly portions of Pennsylvania the producers depend to a considerable extent on the old-time spring houses, where the milk is cooled by running spring water of a temperature of some 52° to 54° F. These spring houses are "hold-overs" from old butter-making days. In some instances there is too much decaying wood about them to make them ideal. Dealers try to have the milk delivered at the station at from 55° to 60° F., and a few attempt to have the farmers cool it down to 52° or 53° F.

GENERAL REMARKS CONCERNING THE MILK BUSINESS IN THE COUNTRY.

For conveying the milk to the railroad stations the farmers use any farm wagons which they may happen to have. More mules are used for draft purposes than are seen in connection with the New York or Boston supply. The milk for the most part reaches the station only a few minutes before the train is due, and it is not many minutes from the farmer's wagon to the car.

The average dairy contains from 15 to 20 cows and produces from 80 to 120 quarts of milk daily. Some of the big dairies produce from 300 to 400 quarts of milk daily.

One of the great drawbacks to the business in Philadelphia, as elsewhere, is uneven production. Sometimes when there is a surplus, producers are asked to hold back one day's supply every seventh day. There is a large seashore demand from the New Jersey resorts, and this helps to even up the supply on the Philadelphia market. It is claimed that there is now a tendency among the farmers to more even production. One dealer said that many farmers who once produced, for instance, 160 quarts per day in the summer, and 40 in the winter, now produce 160 in the summer and 80 in the winter. The average farmer's haul was variously estimated at from 1½ to 2½ miles, with probably about 4 miles as the maximum. There are receiving stations in the country for handling most of the supply of long-distance milk.

One exception may be mentioned to the usual way of doing business. One dealer had a shipping station at which deliveries were made twice a day, the milk being brought in while still warm and promptly cooled and aerated at the station.

WORK OF THE PHILADELPHIA PEDIATRIC SOCIETY.

The Philadelphia Pediatric Society is, as the name implies, an association of Philadelphia physicians who are especially interested in the treatment of diseases of children. It was organized in 1895 for hearing and discussing papers on the disorders of children. A society with such a mission naturally early in its history considered the milk question, and in 1898 a committee was appointed to take some definite steps looking to securing better milk for babies (particularly those who were not strong) than could be obtained from the ordinary milk dealer. This committee submitted its report, which was accepted, and the scheme suggested was under way in 1900. This organization proceeded on the theory that the best milk for infant feeding is natural untreated milk from healthy cows, produced under sanitary conditions, and absolutely sweet and clean. The committee having this matter in charge is known as the "Milk Commission of the Philadelphia Pediatric Society." The work is done gratuitously for the sake of improving the milk supply, the only expense being for inspection, which is paid by the dairies inspected. The regulations call for the periodical examination of the health of the cows, the cleanliness of the dairy, the care and cleanliness observed in milking, the care of the utensils used, the nature and quality of the food, and the health of the employees on the farm. In more detail, this means that the cows must be tested with tuberculin, the stables must have an abundance of light, there must be some satisfactory system of ventilation, the dairy room must be free from stable odors, the stable gutters must be frequently cleaned, and the cows must be kept dry and clean; the stables must be so constructed that they can be kept clean at all times, the water supply must be pure, the dairy room must have a sterilizer for bottles and other utensils, and the milk must be immediately cooled and bottled in a room apart from the stable and free from odor and dust.

The milk which results from this care is regularly examined chemically and bacteriologically to ascertain if all of the requirements as to health and cleanliness have been met and to see that there is no adulteration. It must range from 1.029 to 1.034 specific gravity, be neutral or faintly acid in reaction, contain between 3.5 and 4.5 per cent proteid, from 4 to 5 per cent sugar, and not less than 3.5 per cent fat; it must be free from all contaminating foreign matter and from all addition of chemical substances or coloring matter. It must further be free from pus and injurious germs and have not more than 10,000 bacteria of any kind to the cubic centimeter. If milk meets all these conditions a certificate is issued. Cream is also certified to as to the amount of fat, and in the case of cream a bacterial limit of

25,000 is allowed. These certificates are issued each month and are good for that month only. If at any time the inspections show imperfect conditions, or if the milk in any way fails to come up to the standard, the certificates are withheld for the following month. The certificates read as follows:

PHILADELPHIA PEDIATRIC SOCIETY.

Milk commission certificate.

——— ———, 1905.

Milk from the dairy of ——— ——— has been recently examined by the experts of the milk commission and found to be fully up to the required standards. Another examination will be made within a month and, if satisfactory, new labels for the bottles will be issued, dated ———, 1905.

Notice the dates.

A facsimile of one of the certificates, printed in small size, accompanies each bottle of milk, either pasted over the mouth of the jar or otherwise attached to it.

When these regulations and this standard were adopted, the dairymen of the city were invited to avail themselves of the advantages offered by the society. The circular which was issued stated:

If you do not wish to have your milk so examined, the commission does nothing prejudicial to your interests; but it is believed that it would be to the advantage of the physicians and the better class of milk producers to have some such method of examination under the supervision of a committee appointed by the society, composed of physicians interested in the welfare and treatment of children.

Thus the matter of milk examination is entirely voluntary and no dairyman is obliged to enter into the scheme or to continue in it.

When the plan was broached it suggested considerable extra expense, with the uncertainty of getting any additional income. Consequently less than half a dozen dairies asked to have their milk certified. But those who did take up the matter found that there was a demand for that kind of milk, and the amount of milk and cream certified has gradually increased until at the present time the commission is putting out over 113,000 certificates per month, which represents the product of over 400 cows. This growth is regarded as satisfactory by the commission and the reputation of the plan is spreading, and inquiries concerning it are frequently received, some of them coming from foreign countries. One gratifying feature of the plan is its popularity with the public. Those who use this certified milk are perfectly willing to pay the extra price required. The interest in the measure is evidenced by the fact that if for any reason the certificate of any dairy is withheld, the fact is noticed at once by many consumers and inquiries are at once made of the commission as to the cause of the nonappearance of the certificate. In noting

the few dairymen who have adopted the plan of supplying certified milk it should be remembered that the standard is very high, because the prime object of the Pediatric Society is to get the best unpasteurized milk possible for infant feeding, rather than to raise the quality of the general city supply.

DESCRIPTION OF A CERTIFIED MILK DAIRY.

One dairy which has built up its business exclusively on the certified advertisement was visited by the writer. One hundred and fifty-five cows are milked. The cows are grade Guernseys and Holsteins. The cow barns are one story high, with monitor roof for ventilation. Windows are numerous, and the place fairly glistens with bright whitewash. The stanchions and all the supporting framework are of iron pipe. The floor is of cement. As each cow is milked the milk is taken to an adjoining room, where an attendant weighs it, makes a record of the weight, and turns the milk into a 40-quart can. As soon as this is filled it is transported by a cable carrier to the dairy building. The interior of the dairy room is entirely of cement, including floors, walls, and ceiling. Screens keep out all flies. The dairy room is also fitted with all needed appliances for washing and sterilizing the bottles before milk is put into them. The sinks are of soapstone. The cooler hangs in the middle of the dairy room. There are no corners or angles to catch or conceal dirt, and everything is spotlessly clean.

Here the milk is cooled and bottled, the bottles placed in boxes holding one dozen each, and packed in ice. It leaves the farm at 9.35 p. m. and reaches the city at 11 p. m. The delivery begins about 3 in the morning. This dairy has its own teams and men in the city, so that the whole process of production and delivery is under its control.

When the milk is bottled the usual pasteboard cap is placed over the top of the bottle, then the certificate of the Pediatric Society is placed over that, and a round piece of parchment paper 5¼ inches in diameter is placed over the whole and held in place by a rubber band. On the top of the bottle the name of the dairy and the inscription "Five per cent butter fat" or "Four per cent butter fat," as the case may be, are in plain sight. Cream is put up in the same way, with a label "Sixteen per cent butter fat" or "Twenty-five per cent butter fat," as the case may be. This milk retails in Philadelphia for 12 cents per quart, or 7 cents per pint. It retails in Atlantic City in the summer for 16 cents per quart. It is sometimes claimed in other places that the public is not educated to know the different values of different grades of milk, but the customers of the dairy are very quick to note the fact and complain if by accident a driver may

happen to deliver a can of 4 per cent milk instead of 5 per cent. Both kinds, however, are retailed at the same price, as the managers claim that there is no difference in the cost of production.

This milk is regularly tested for bacteria, and usually ranges between 500 and 1,000 per cubic centimeter. In exceptional cases the number rises to 5,000. But the Pediatric Society allows 10,000. In this connection it is interesting to note, for purposes of comparison, that the Boston Board of Health has made a standard for the general supply of that city of 500,000.

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(Continued from second page of cover.)

Dr. W. B. Lincoln, care Tennessee Packing and Provision Co., Nashville, Tenn.
Dr. A. Long, care Sperry & Barnes, New Haven, Conn.
Dr. C. Loveberry, room 402, Custom-House (new), Portland, Oreg.
Dr. H. D. Mayne, Malone, N. Y.
Dr. Louis Metsker, room 22, N. T. Armijo Building, Albuquerque, N. Mex.
Dr. J. Miller, care John Morrell & Co., Ottumwa, Iowa.
Dr. C. L. Morin, St. Albans, Vt.
Dr. A. B. Morse, care The Agar Packing Co., Des Moines, Iowa.
Dr. W. J. Murphy, care Springfield Provision Co., Brightwood, Mass.
Dr. W. N. Neil, care John Cudahy Co., Wichita, Kans.
Dr. V. A. Nörgaard, Honolulu, Hawaii.
Dr. F. M. Perry, Fort Fairfield, Me.
Dr. G. W. Pope, Animal Quarantine Station, Athenia, N. J.
Dr. H. T. Potter, Calais, Me.
Dr. J. O. F. Price, care Brittain & Co., Marshalltown, Iowa.
Dr. R. A. Ramsay, Fargo, N. Dak.
Dr. A. G. G. Richardson, 707 Empire Building, Knoxville, Tenn.
Dr. A. E. Rishel, care Cudahy Packing Co., Los Angeles, Cal.
Dr. W. H. Rose, 18 Broadway, New York, N. Y.
Dr. F. L. Russell, Orono, Me.
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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY.—BULLETIN No. 82.

A. D. MELVIN, CHIEF OF BUREAU.

FUNGI IN CHEESE RIPENING:

CAMEMBERT AND ROQUEFORT.

BY

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WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1906.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., February 6, 1906.

SIR: I have the honor to transmit herewith the manuscript of an article entitled "Fungi in Cheese Ripening: Camembert and Roquefort," by Charles Thom, Ph. D., and to recommend its publication as Bulletin No. 82 of the series of this Bureau. This is the second paper dealing with the cooperative experiments in soft-cheese making undertaken by the Dairy Division of this Bureau in conjunction with the Storrs (Conn.) Agricultural Experiment Station, the first paper having been published as Bulletin No. 71 of this Bureau.

These experiments have been carried on at the Storrs Station under the general direction of Prof. L. A. Clinton, the station director, and under the personal supervision of Dr. H. W. Conn, the station bacteriologist, in accordance with the plan outlined in the introduction to Bulletin No. 71.

While there are many problems yet to be investigated with reference to the manufacture in this country of soft cheeses of the best European types, this article indicates that good headway is being made in that direction, and it is believed that the information here presented is of considerable scientific and economic value.

Respectfully,

A. D. MELVIN,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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INTRODUCTION.

It has been shown in a previous bulletin that certain fungi are the active agents indispensable to the ripening of Camembert cheese. The general results and the data upon which they rest are there discussed, but the more special mycological studies, involving several lines of work, remained to be brought out in greater detail. These fall naturally under two heads: (1) The physiological studies of the functions of particular species in the ripening processes of Camembert, Roquefort, and certain related types of cheese; (2) the classification and description of these and other forms occurring in dairy work. This paper includes only the work done under the first head. The description of the fungi occurring in dairy work is reserved for another paper.

Aside from such obligations as are mentioned in the discussion of special topics, the author wishes to acknowledge the assistance of Dr. B. B. Turner, Prof. W. A. Stocking, Mr. A. W. Bosworth, and Mr. T. W. Issajeff, members of the experiment station staff, in numerous cases where the work of each presupposes the results of the other, and especially to acknowledge the constant assistance of the supervisor of the investigation, Dr. H. W. Conn, with whom the cheese problems have been fully discussed at every stage.

CAMEMBERT CHEESE.

RÉSUMÉ OF PREVIOUS PAPER.

The biological conditions and the physical changes encountered in the production of a Camembert cheese from market milk may be restated from our former bulletin[1][a] as a basis for defining the special problems of the mycologist.

Milk as ordinarily received contains bacteria of many species and the germinating spores of numerous fungi from the stable and from the food of the cattle. When such milk is curdled for cheese making,

[a] The figure references are to bibliography at end of bulletin.

representatives of all of these species are inclosed in the mass of coagulum. Freshly made cheese from this curd, then, may contain any species of mold or bacterium found in the locality which is capable of living in milk or its products. The first step in the ripening of a Camembert cheese is the production of lactic acid. The lactic bacteria very soon increase their rate of multiplication so enormously as to become entirely dominant. The acid produced by these forms soon reaches a percentage sufficiently high to restrict the further growth of nearly every other species of bacteria, and even to eliminate the organisms themselves. In a time varying from a few hours to three or four days, according to the proportional numbers of these antagonistic species at the start, further bacterial growth seems to be entirely stopped. Bacterial development can not begin again until this acidity is reduced below the critical point for the species involved, and even then, since the acid is neutralized on the outside first, for most species it begins at the surface and works slowly inward. The uncertainties due to the presence of many species of bacteria in the milk are in this way avoided by the natural, simple, and almost universally successful process of souring.

The further ripening of a Camembert cheese is attended by a gradual reduction of this acidity until the ripe cheese is usually alkaline to litmus. At the same time the mold action in the mass of curd produces chemical changes which in from three to five weeks reduce the previously insoluble mass to a high percentage of solubility in water. In the later stages of this breaking down compounds are formed which give the characteristic odors and flavors to this type of cheese. Associated with these chemical changes there is a progressive physical change from the firm curd to a soft, buttery, or even semiliquid texture, characteristic of ripe cheese. The biological problems then were, in general, the determination of what organisms cause—

(1) The changes in the acidity of the curd.

(2) The breaking down of the casein, with the associated changes in the physical character of the cheese.

(3) The production of the flavors.

(4) The recognition and control of deleterious species.

CULTURE MEDIA AND METHODS.

The common dairy fungi grow readily upon any of the standard culture media. Among the media used have been peptone agar, whey gelatin, sugar gelatin with or without the addition of litmus, milk agar, gelatin and agar made with Raulin's fluid, potato agar, potato plugs, and sterilized milk and curd. Special studies have involved other preparations. The fact that these fungi grow readily upon all the common media has led to the selection of two preparations for constant use, and the careful study upon these of all species found. For

this purpose the sugar gelatin, described by Conn[2] for the qualitative bacteriological analysis of milk, and potato agar have been used.

The sugar-gelatin formula produces an accurately titrated medium in which every effort is made to secure a uniform composition. Although absolute uniformity in chemical and physical properties is never obtained, the reaction of many species of fungi, when grown upon successive lots of gelatin made after this formula, have been so reliable as to commend its use for determining physiological characters. It seems clearly shown, therefore, that slight variations in the composition of the medium do not produce great differences in the species studied in this paper. In the discussion of the relation of a mold to this gelatin it must be borne in mind that the same results might not follow the use of any other formula.

The other medium, the potato agar, was selected because of its use in many mycological laboratories. In this medium uniform composition can hardly be claimed. The following process has been used in this work: The potatoes are carefully washed, pared, and sliced, then slowly heated for about two hours in approximately two volumes of water. At the close of the heating the water is allowed to boil. The whole is then filtered through cloth, and commonly through cotton also, water being added to make up the losses of evaporation and filtering. To this is added 1 per cent of shredded agar. It is then heated for from twenty to thirty minutes in the autoclave to 120° C. or higher, when it may at once be put into tubes for use, or, if cloudy, it may be very quickly filtered through absorbent cotton, after which it should be quite clear. The uncertainties in the composition of this medium result from the differences in the potato extract itself and from the fact that the difficulties in filtering this extract take out a varying amount, which is replaced with water. Titration shows that this medium is nearly neutral (4–6 acid on Fuller's scale) in cases tested to phenolphthalein; consequently it is used without neutralizing. Culture and study of the same species upon successive lots of this medium show that these differences in composition have little if any effect upon the morphology of the species studied.

Petri-dish cultures have been used continually because they admit of direct study under the microscope. Slanted test tubes were found useful for stock cultures and for gross studies of physiological effects, but they are of little value for comparative work. It is useless to attempt to get a correct idea of the normal gross structure of these molds from fluid mounts. The extremely delicate hyphæ are so tangled in such preparations as to give but very little idea of their ordinary appearance, while the chains of conidia break up immediately when placed in any fluid. Such mounts are useful and necessary to get at details of cell structure and cell relations, but in comparative

studies of species of such a genus as Penicillium their value is only that of a useful accessory. The primary source of comparative data must be direct study of the growing colony, undisturbed upon the culture medium, with the best lenses that admit of such use.

This method of study recognizes that morphology is the basis of fungus determination, but takes into consideration—

(1) That morphology must not only include the minutest details of cell structure and cell relations such as are undisturbed in fluid mounts, but also the appearance and character of the colony.

(2) That the morphology of the colony—i. e., the size of conidiophore and fructification, relation of these to substratum, appearance, and relations of aerial and submerged mycelium—is different upon various substrata, but has been found to be characteristic for each particular substratum.

(3) That a description of morphology to be of value must, therefore, specify the formula of the medium used and the conditions.

Dilution cultures have been necessary usually to obtain the colonies pure, but the direct transfer of large numbers of spores upon a platinum needle to the surface of gelatine or agar plates which have been allowed to cool has been found to give equally reliable results, and to have many advantages for the study of species once obtained in pure culture. This is often spoken of as inoculation of cold-poured plates. Litmus solution may be used with either gelatin or agar, and gives striking evidence of differences in species and the rate of their physiological action. Bacterial contamination has been usually restrained by the addition of from 2 to 4 drops of normal lactic acid to 8 or 10 c. c. of medium.

EFFECT OF A FUNGUS UPON A CULTURE MEDIUM.

In studying the relation of a fungus to a culture medium we find (1) that the fungus absorbs food from the surrounding medium; (2) that it may secrete or excrete substances into the medium which may transform its chemical composition and its appearance. The amount of food absorbed by the fungus is small, and for our purposes may be practically ignored, but the changes induced by indirect action—secretions from the mycelium—are great and far-reaching. To this latter group belong the changes in acidity, digestive effects, and flavors produced by fungi.

LITERATURE OF CHEESE FUNGI.

A review of the literature at the outset showed that no work on the fungous flora of the various types of soft cheese had been published in English. Epstein,[3] at Prague, studied the ripening of Camembert and Brie cheeses. He attributes the breaking down of the curd in French Brie to the action of *Penicillium album*, but denies the participation

of molds in the ripening of Camembert. Johan-Olsen,[4] in Sweden, has published a brief review of the fungi related to the ripening of Gammelost, barely mentioning work done upon Camembert. Constantin and Ray,[5] in France, have described the appearance upon the cheese of the species of Penicillium involved in the ripening of the French Brie. Roger,[6] also in France, has attributed a single phase of Camembert cheese ripening to the activity of *Penicillium candidum*, for which he gives no description. Of these references, that of Epstein and that of Constantin and Ray describe the mold found upon the French Brie sufficiently clearly to aid in its recognition. A popular article, signed Margaret,[7] in the Creamery Journal of October, 1904, gives in entirely untechnical language a very satisfactory description of the appearance upon cheese of the penicillium concerned in the ripening of Camembert. The general insufficiency of the literature available made a first-hand study of the types of cheese found in American markets the only source from which definite information could be secured.

BIOLOGICAL ANALYSIS OF A CHEESE.

In the biological analysis of a market cheese it is carefully unwrapped to avoid contamination as far as possible. Series of dilution cultures on neutral and acid media are made at once from each part of its surface which shows any variation in appearance. In this way all the surface molds and bacteria are secured in one set of plates. Afterwards this surface is examined in detail, usually with a lens, the appearance of the different areas being noted, and direct transfers from each area made to cold agar or gelatin plates. The cheese is then cut with a sterilized scalpel and cultures are made from various portions of the interior. Usually the transfers were made from the center and from the area just inside the rind. Any part showing special appearances is reserved for a separate series of cultures.

Most of the brands of Camembert cheese found in our markets, as well as some sent by Roger, have been examined in this way. For comparison, similar studies have been made from several specimens of Roquefort cheese bought in different markets, and from individual specimens of Gorgonzola and Stilton. Single studies for molds have been made from Limburger, Port du Salut, Brinse, and from several brands of prepared cheese found in the market. From these cultures all species of bacteria found have been isolated and handed over to the bacteriologists. Each variety of mold occurring upon these cheeses has been isolated and studied. It has been possible in this way to show that a comparatively small number of species characteristically occur upon soft cheese. Although this list may be greatly extended by including forms which are occasionally found, it is rather surprising that a restricted group of species occurs with much regularity in studies of cheese from so widely different countries.

To study the origin and distribution of these molds several laboratories and cheese factories have been visited and cultures taken. Correspondents in distant States have kindly sent cultures of molds occurring in their work. Among those who have sent material are Dr. C. E. Marshall, Agricultural College, Mich.; Mr. E. G. Hastings, Madison, Wis.; Prof. F. C. Harrison, Guelph, Ontario; Dr. H. A. Harding, Geneva, N. Y., and Prof. P. H. Rolfs, Miami, Fla. Thus, in addition to a large number of cultures from the dairy laboratories of the stations at Storrs and at Middletown, we have accumulated from various sources a considerable number of species representing the characteristic molds occurring in dairy work, as well as many forms collected in the field and from laboratories not associated with dairy investigation.

THE FLORA OF CAMEMBERT CHEESE.

Although a considerable variety of molds appeared in cultures from Camembert cheeses, a list of possibly twenty species would include those which were often found. Among these there are perhaps six species of Penicillium, two or three of Aspergillus, *Oidium lactis*, *Cladosporium herbarum*, one or two of Mucor, one or more of Fusarium, *Monilia candida*, and two species perhaps related to it, with the incidental occurrence of *Acrostalagmus cinnabarinus*, a Cephalosporium, various species of Alternaria, and Stysanus. Besides these, yeasts in large numbers and considerable variety are found in many cases.

The comparison of the results of culture with comparative studies of the surfaces of different brands of cheese showed that a single species of Penicillium was present upon every Camembert cheese examined. In partially ripened cheeses this mold often covered the larger part of the surface. We shall call this the "Camembert Penicillium" or the "Camembert mold." This species develops a large and characteristic growth of aerial mycelium in addition to a densely felted mass of threads which penetrate the surface of the cheese for 1 or 2 mm. and largely constitute the rind. In all except a few very old cheeses which were almost covered with red slime of bacterial origin it was readily seen to be the dominant species upon the surface.

Similarly, cultural data showed *Oidium* (*Oöspora*) *lactis* to be abundant upon every brand of Camembert. This mold is practically indistinguishable upon the surface by its characters, except under very favorable conditions, and at best its recognition, even with a hand lens, is not often certain. Mycelium of this fungus develops only in very moist substrata, and is usually entirely submerged. Only part of its chains of conidia even rise above the surface. In old and very ripe cheese, when the rind is covered with yeasts and bacteria, it is often difficult under the microscope to find the spores of Oidium. In such cases, unless one is familiar with the peculiar smell associated with its

action, he must depend entirely upon the culture for evidence of its presence.

No other species of mold has been found upon every cheese examined, although no market cheese has failed to show contamination with at least one or two of the other fungi listed above. In other words, comparative biological examination of imported Camembert cheeses established the fact that these two species of mold were present upon them all, however abundantly they might be contaminated with other forms. The examination of hundreds of cheeses in the city markets has shown the presence of the same two molds upon all the brands of Camembert offered for sale. Such analyses clearly established the presence of these molds upon the ripe cheese, but gave no information either as to whether they were necessary or what function, if any, they might have. Experiments were therefore devised to test the relationship of these molds to the ripening processes outlined above. The constant occurrence of other molds upon the cheese brings up the question, How and to what extent do the latter affect the ripening process? The experiments, therefore, have been made to include as many species as possible. Where detailed chemical analyses had to be made the work has necessarily been restricted to a few forms.

For this purpose, in addition to the Camembert Penicillium and *Oidium lactis*, the Penicillium found in Roquefort cheese ("der Edelpilz" of German authors) has been generally used. For convenience it is called the "Roquefort Penicillium" or "Roquefort mold." One of the Mucors, probably *Mucor* or *Chlamydomucor racemosus*, is so commonly found that it has often been included. A pure white mold closely related to the Camembert Penicillium has given some interesting contrasts. When reference is made to any of the numerous undetermined green species of Penicillium, they will be indicated by the letter or number under which they appear in the record book of cultures, and under which the origin and subsequent cultural history of all species studied has been kept.

OUTLINE OF THE WORK.

These studies involve two classes of data, first, those experiments requiring quantitative analyses, which have been conducted in cooperation with Mr. A. W. Bosworth, chemist to this investigation, the results of which series of analyses will appear in his report; second, experiments which show the physiological characters of the fungi by physical changes in the appearance, texture, or color of the medium used, or by the production of flavors.

The results may be anticipated here by noting that these two classes of data did not prove mutually interdependent, but that analysis may show in general the right stage of chemical changes called for in a ripe

cheese without the necessary texture and flavor; and, conversely, the practically necessary texture and flavor may be obtained in a cheese differing considerably in its chemical characteristics from the standard market article. In our practical experiments we sought first for proper appearance, texture, and flavor of the cheeses; then, without disturbing these, endeavored so to control the processes of ripening as to satisfy the standard of chemical composition established from the study of market cheeses.

RELATION OF MOLDS TO ACIDITY.

The development of lactic acid has been shown to be of primary importance in the control of deleterious bacteria. In our previous paper it has also been seen that after doing its work this acidity gradually disappears in the ripening process. The disappearance of the acid has been attributed by Roger,[6] by Epstein,[8] and by Mazé[9] to the activity of molds, and interpreted as preparing the way for the action of peptonizing bacteria. This view of the relation of molds to cheese ripening has been widely quoted as their only function in the process.

The acid exerts practically no selective action upon any of the molds studied. Stoll has recently shown that species of Penicillium grow readily in media containing a much higher percentage of acid than ever occurs in cheese work. The use of acid in fungous cultures to restrain bacteria is practically universal, but the action of the different species of mold upon the acid is very different. This is strikingly shown by the introduction of a solution of litmus into the culture media used. Litmus gelatin or litmus agar may be a deep blue if used at 15 acid on Fuller's scale, as is usual for bacterial studies, or a clear bright red if 2 to 4 drops of normal lactic or other acid are added to 10 c. c. of medium. No mold cultivated in this work has failed to show some definite relation to acidity indicated by litmus reaction. Some fungi, as soon as they develop visible colonies, begin to change red (acid) media to blue (alkaline), and consistently maintain this character. Many others, when grown in blue gelatin (designating by blue gelatin 15 points acid to phenolphthalein = 10 points alkaline to litmus on Fuller's scale), begin by changing the blue to red. This change may vary from the faintest tinge of red in only that part of the medium directly in contact with the threads of the young colony to deep red over large areas. *Oidium lactis* and Roquefort Penicillium produce at times a very slight pink, which barely traces the outer limits of the young colonies before the blue reaction begins to appear. At other times the red, if appearing at all, has been so evanescent as to be overlooked. It has been suggested that this slight appearance of acidity might be due to the excretion of carbon dioxide in respiration, which, although continuous, is afterwards masked by many times larger changes in other substances.

The Camembert Penicillium, and several of the very common green species of Penicillium, when grown upon blue gelatin, at first turn all the substratum in contact with the growing colonies to a bright red. Some species produce areas of red beyond the limits of the mycelium. These effects are most clearly seen by examining the colony from the under side. Later a spot of blue appears in the center of the colony below and gradually extends outward until commonly the entire mass of culture medium has become blue. This often involves a change of reaction in agar or gelatin 2 to 3 cm. beyond the colony. It is thus clear that there must be either the secretion or the excretion by the mycelium into the medium of a substance capable of changing this reaction or the absorption from the medium of some substance, thus changing its reaction. The exact nature of this change has not been determined. Increase in the percentage of acidity or of alkalinity retards the change of reaction. In certain experiments phenolphthalein was introduced into red litmus media and several species of Penicillium and *Oidium lactis* were grown upon it. With the Camembert Penicillium the entire mass of agar became blue in a few days, and remained so for nearly three weeks. Then the characteristic pink color for the alkaline reaction of phenolphthalein appeared on the under side of the colony. This was tested by opening the colony with a platinum needle and introducing a very small drop of normal acid, when the pink area was changed first to blue and then to red. As the acid diffused outward from the center the wave of blue traveled outward, being replaced constantly by red until all trace of the phenolphthalein reaction was gone. The other species used did not give this reaction. There are forms including some species of Penicillium, *Aspergillus niger*, *Monilia fructigena*, and others, which produce the acid reaction in litmus media without any change to blue. Several species of Penicillium rapidly produce the purplish color which is characteristic of the turning point of litmus at which their further development occurs. Apparently these bring acid or alkaline media to that point without further change. It would appear, then, that the relations of these molds to acidity, as indicated by the litmus reaction, is reasonably uniform. To determine whether the litmus reaction would be reliable upon a medium closely allied to cheese, test tubes of separated milk were prepared, blue litmus added, and the tubes sterilized. Eleven species of Penicillium were inoculated into these tubes and observations made every day. Of the eleven species, four, including the Camembert Penicillium, produced a layer of red milk for a few millimeters below the colonies, which later was changed back to blue. The other species either intensified the blue or produced no change.

The suggestion has been made that neutralization of acid is due to the production of ammonia. A series of cultures were made in

cooperation with Mr. A. W. Bosworth to test the production of ammonia compounds by mold action. The species used were the Roquefort Penicillium, the Camembert Penicillium, *Penicillium* sp. (record No. 310), *Oidium lactis*, *Oidium* sp. (record B), and *Aspergillus niger*. These were grown upon potato ager, to which litmus and lactic acid were added. The Aspergillus culture remained bright red; all the others became deep blue. Upon analysis the *Aspergillus niger* was found to have produced the largest amount of ammonia. Study of the figures showed that the ammonia alone was not sufficient to neutralize the acid used in any case. It is clear, then, that the lactic acid must have been neutralized by some other basic products of digestion rather than by ammonia. If the acid were absorbed and dissociated after absorption the area of blue would be restricted to the neighborhood of the hyphæ, or the diffusion of the acid for considerable distances would produce purple tones instead of sharply marked areas of red and blue. The data seem to indicate that chemical decomposition or neutralization of acid must be the action of some product excreted by the fungus, probably an enzyme.

It has thus been shown by many experiments that the Camembert Penicillium and *Oidium lactis* are two of many species capable of reducing the acidity of the media upon which they grow. Many other species of the same genus produce this effect more quickly than the Camembert Penicillium and some act at about the same rate. The reduction of the acidity of the cheese may clearly be attributed to these molds; but the study of the relations of many other molds to acid indicates that any of a large number of species might be equally or more useful for the accomplishment of this step in cheese ripening. If, therefore, these particular molds are essential to Camembert cheese ripening, their special function must be sought in other steps of the process.

THE BREAKING DOWN OF CASEIN.

The changes in firm sour curd which result in the production of the soft, buttery, or semiliquid texture of the Camembert cheese present some very complex problems. These may be grouped as (1) the purely chemical questions, which involve qualitative and quantitative analyses of the material at every stage; (2) The biological and physical questions, which deal with the agents and conditions which produce these results and with the gross appearances of the final products, whose descriptions do not depend upon detailed chemical analysis.

(1) The chemist describes the general course and extent of these processes[1] as a change in which the insoluble or but slightly soluble compounds of casein found in sour curd are rendered almost completely soluble in water. The details of the process and the data will appear later in the report of the chemist.

(2) To determine what relation the molds might have to this change involved a great many cultures on different media. In some experiments the number of species used was large and the results acquired in that way a comparative value, but in the more complicated trials the work was limited to those mentioned above.

It is practically impossible to produce a normal cheese in such a way as to avoid contamination with bacteria or molds. It is difficult, therefore, to study directly upon cheese the relations of organisms to the steps of cheese ripening. Even were this possible, the complexity of the changes encountered would make the interpretation of the phenomena difficult. The activities of these molds have, therefore, been studied in pure culture upon a series of media which would give information as to steps of the process. While these cultural studies were proceeding, many cheeses were made and inoculated with the Camembert and Roquefort Penicillia. The measure of success obtained from cheese inoculated with the Camembert Penicillium gave good, practical ground for its continued study. These detail studies may be discussed best separately.

LIQUEFACTION OF GELATIN.

The liquefaction of gelatin media has been much used as an index of digestive activity. All species obtained have been grown upon neutral and acid sugar gelatin and the effects noted carefully.

The difference in action between the molds important in this investigation are striking. The Mucor produces a slow but rather complete liquefaction; *Oidium lactis* will gradually soften the gelatin so that the center of the colony is liquefied; a pigment-producing Penicillium (recorded simply as O) will liquefy all the gelatin in contact with it so quickly that it becomes in a week a floating colony in a watery pool twice its own diameter. Several other species of Penicillium have the same effect. The Roquefort Penicillium softens gelatin somewhat, but never produces a watery liquefaction. The Camembert Penicillium often produces a slight liquefaction under the center of the colony, but never extends that liquid area to half the total size of the colony. This seems to indicate that the Penicillium O and its allies would produce a rapid digestion, that the Mucor would be somewhat slower, that the Camembert mold might have some digestive effect and the Roquefort mold very little, if any, value. The test of the ability to liquefy the gelatin used gives, therefore, only indefinite or negative results as to any advantageous relation of these particular species to cheese ripening.

Comparative study of numerous cultures of many species of fungi upon gelatin gives, however, some very interesting suggestions. In many species which liquefy litmus gelatin rapidly, the area of liquefaction is surrounded by a blue (alkaline) band. For example, in one

experiment with Penicillium 392 at its most active period of growth a colony 15 mm. in diameter was surrounded by a liquefied area 4 to 8 mm. wide. This area was in turn surrounded by a band of intense blue shading gradually in a width of perhaps 10 mm. into unchanged red litmus gelatin. The medium which had been liquefied was almost colorless.

Several suggestions may be drawn from many such observations. The change in acidity of the medium, as has been noted above, may be effected at a distance of 2 to 3 cm. from the colony. This change of litmus reaction advances faster than the area of liquefaction of the gelatin. The breadth of the area of liquefaction shows that the action of the fungus is not a digestion by contact, but the secretion into the medium of diffusible agents, that is, enzymes. In most of these species liquefaction occurs only in areas having alkaline reaction. No general relation between acidity and digestion is established. The substantial uniformity of the results of repeated cultures of the same species of fungi upon gelatin made after the formula used established its usefulness as a test of the ability of an organism to perform this particular digestion. It will be shown later that the ability to liquefy this variety of gelatin is not to be regarded as a general test of the ability of a species to produce active proteolytic enzymes.

RAULIN'S FLUID.

To test the ability of these species to grow in a medium entirely lacking in proteid, Raulin's fluid was used as given by Smith and Swingle,[10] but modified by leaving out the potassium silicate and zinc sulphate. Sterilized flasks of this solution were inoculated with Mucor, *Oidium lactis*, Camembert Penicillium, and Roquefort Penicillium. All four grew. The *Oidium lactis* and Mucor did not appear to develop in an entirely normal way. Both species of Penicillium grew richly and fruited normally. The culture of the Camembert mold, after growing several weeks, was examined chemically and digestive experiments conducted by Mr. Bosworth demonstrated the presence of a proteolytic enzyme. In this way it was shown that this fungus could not only construct proteid from inorganic compounds of nitrogen, but would produce proteolytic enzymes in such a solution. Enzyme studies were not made for the other species used in this experiment.

CASEIN.

For a medium at the opposite extreme, the chemists prepared pure casein. This was weighed into 2-gram lots, moistened, sterilized in the autoclave, and inoculated with five species of mold. All grew and fruited luxuriantly. This experiment showed only that the species used were able to break down casein and to grow normally upon the products of this digestion without the addition of other nutrients.

STERILE MILK AND CURD.

Sterilized milk and sterilized curd offer a substratum related to cheese. Sterilized milk in quantities varying from 40 c. c. to 150 c. c. in test tubes and Erlenmeyer flasks has often been used. Nearly all species of Penicillium grow luxuriantly, forming a felted mass of mycelium often 2 to 4 mm. in thickness upon the surface of the milk. With the absorption of the milk in such cultures of the Camembert and Roquefort species the mass of mycelium buckles and bends, tubercles of mycelium arise on the under side of the mass and grow downward, keeping the mold in connection with the fluid. In this way a culture may continue to grow for several months until it forms tough, irregular masses of felted hyphæ, filling the test tube for an inch or more downward from the original surface of the milk. The milk below the colony soon becomes transparent, giving reactions for digestion, with a residue of curd at the bottom, which in the course of time may be almost completely dissolved. With the *Oidium lactis*, on the contrary, the colonies largely sink below the surface, so that the milk may be quite well filled with mycelium upon which chains of spores are only produced in quantity at or just below the surface. Similar experiments with 100 grams of sterilized curd in flasks, inoculated with the Camembert and Roquefort molds, have shown that either species is able to change the chemical composition until the derivatives of casein are amost completely water soluble. Such cultures were plated to show their freedom from contamination by bacteria before analysis. The resulting products give the standard reactions for digestion. These experiments show that either of these molds is capable of producing digestive changes comparable in their completeness, rapidity, and general nature to those shown by analysis to have occurred in the ripening of Camembert cheeses.

DOES THE MYCELIUM PENETRATE THE CHEESE?

It must be noted carefully that this action of the Camembert mold goes on without the complete penetration of the substratum by the mycelium of the mold. That this is true is readily seen in milk cultures, where the limits of the development of the mycelium are sharp and clear. The same fact has been demonstrated for cheese by hundreds of sections and careful cultural studies many times repeated. The mycelium forms a dense mat upon the surface of the fluid or the mass of curd, or the newly made cheese. It follows the irregularities of the surface and is not found to enter well-packed curd to any extent. It is very difficult to prove that hyphæ of this mold actually appear in curd of uniform texture below 1 or 2 mm. When found deeper, careful search usually shows a cracking of the surface, so that the mycelium may follow the opening already made. In no case of many hundreds

of cheeses studied and experiments performed has the mold been found to fruit in cavities not opening broadly upon the surface. This is in marked contrast to the habit of the Penicillium instrumental in the ripening of Roquefort cheese, which penetrates the channels of the substratum and fruits in every cavity large enough to accommodate a conidiophore. The Roquefort mold will make every cavity in a cracker or piece of bread green with spores, while the Camembert mold will fruit upon the surface of the bread or cracker with only vegetative mycelium inside the bread.

Definite experiments to prove that this digestive power on the part of the Penicillium is due to the secretion of one or more enzymes have given characteristic reactions for digestion many times. Without here discussing these chemical reactions, it has been shown that the chemical action of the fungus is carried on at distances from the mycelium which preclude direct action. The enzyme must therefore be secreted and diffuse outward from the mycelium into the substratum. This explains why the Camembert cheese begins to ripen just under the surface and the process progresses inward from all sides until the cheese is entirely ripe. Before this process is complete the center is simply sour curd. A good illustration of this action is seen in cheeses which are ripened without turning. In such cases the development of mold and enzyme on the lower surface is prevented, and as a consequence ripening is delayed on that surface.

CAMEMBERT PENICILLIUM UPON CHEESE.

Many cheeses have been made and inoculated with this mold in conjunction with pure cultures of lactic starter. Little difficulty is found in this, since, if an abundance of spores are put upon the cheese when made, this mold seems capable of taking and maintaining the lead of all others. A cheese made in this way and ripened for from three to four weeks will finally be rendered creamy, or, under some conditions, waxy throughout, in color white within, in flavor almost neutral, having no particular character—good or bad—and hence, to one fond of Camembert cheese, tasteless and insipid. The important features of this ripening process are, then, the completeness of its action and the entire absence of any objectionable character in its flavor. Biological analysis has shown that the center of such a ripened cheese may be practically a pure culture of lactic organisms. The texture is, therefore, obtainable by the use of the Penicillium alone.

COMPARATIVE STUDIES OF FUNGOUS DIGESTION.

Comparative tests of digestive action have been made for a number of molds. The Roquefort Penicillium has been used in parallel cultures with the Camembert Penicillium in many determinations. It

has shown equal or greater ability to digest milk and curd. A typical example of several series consisted of the cultivation of 11 species of Penicillium upon sterilized milk in large test tubes. Observation of results after seven days showed digestion by 7 of these species. In 5 of them the amount of action exceeded that of the Camembert Penicillium, and some of them appeared to digest milk at least twice as rapidly as did that species in the first week.

In another series milk agar was made by dissolving 1 to 2 per cent of the agar in water at 130° C. and pouring together equal quantities of the hot agar and hot sterilized milk. If poured into Petri dishes at once this medium was smooth and clear, but if acidified or sterilized after mixing, flakes of precipitate appeared. The flaky precipitate in the acidified cultures was found very useful as an indication of digestion. In cultures upon the surface of such plates where digestive action was strong the flakes would entirely disappear. Twenty-three species of mold were tested upon milk agar in this way. Of these, 8 produced a distinctly stronger digestion than the Camembert Penicillium; 5 produced digestion approximately equaling that species, and 10 produced less digestion. These cultures were mostly made in duplicate, and both results in all but two cases agreed fully. *Oidium lactis* produced comparatively little effect upon this medium.

TABLE I.—*Reaction of certain species of molds.*

Species.	Litmus.	Liquefaction of gelatin.	Rate of digestion of curd.	Rate of digestion of milk.	5° to 10° C.
Camembert P....	Red, then blue.....	Partial.......	Medium...	Medium......	Grow, slow fruiting.
Roquefort P.....	Blue..............	Softening.....	Rapid	Rapid........	Characteristic growth.
Oidium..........	Blue..............	Incomplete...	Slow......	Slow..........	Characteristic.
Mucor 12.........	Blue..............	Incomplete...	Slow......	....	Poor growth.
Mucor 191........	Blue..............	Incomplete...	Slow......	....	
O................	Blue..............	Rapid........	Rapid	Rapid........	
300..............	Blue..............	Partial.......	Medium to rapid.	Rapid........	Retarded.
132..............	Red, then slowly blue.	Slight........	Medium...	....	
310..............	Red, then blue.....	Slight........	Slow to medium.	Slight........	Slow growth.
68...............	Red, then blue.....	Partial.......	Slow......	Medium......	Slow fruiting.
Monilia candida 198.	Blue..............	Rapid........	Rapid	Rapid........	
P. brevicaule.....	Blue..............	Rapid........	Rapid	Rapid........	
392..............	Blue..............	Rapid........	Slight.....	Rather slow..	
240..............	Blue..............	Rapid........	Rapid	....	
Aspergillus niger.	Red...............	Rapid........	....	Slow..........	
135..............	Blue..............	Rapid........	....	Rapid........	
136..............	Red to purple blue.	Partial softening.	Medium...	....	Characteristic.

Two species of Penicillia, 68 and 310, found closely associated upon cheese with the Camembert Penicillium, produced little digestion. The Roquefort Penicillium and several other molds often found upon Camembert cheese appeared to act much more rapidly than the Camembert mold itself.

All of these series of cultures under different conditions have many times shown the same results and prove that the ability to digest curd is common to many species of fungi. The species we have been led to call the Camembert Penicillium possesses this character in common with numerous other molds, many of which act more rapidly than this one.

After the ability of several molds to digest curd is established, the relation of any particular mold to cheese ripening must be determined by the character of the products of that digestion and the flavors associated with it. No pure culture upon a medium previously sterilized by heat has given a taste resembling that of Camembert cheese. Cheese made and kept in an atmosphere of chloroform, which prevented mold and bacterial development, refused to ripen. Numerous cheeses made and not inoculated with molds have uniformly failed to develop the texture and flavor of Camembert cheese, although such cheeses have usually become covered with molds of various species. The type of cheese made and sold in this country as Isigny and Brie, and sometimes labeled Camembert, which always shows *Oidium lactis* associated with bacteria, differs entirely in appearance, texture, odor, and flavor from Camembert; yet *Oidium lactis* is capable of neutralizing the acid of the cheese much more rapidly than the Camembert Penicillium. Nevertheless the center of such a cheese remains acid for a longer time than is required to ripen a Camembert cheese, while the texture of Camembert is not produced. The necessity for the presence of another agent in this ripening is clearly established.

More than 2,000 cheeses have been made and ripened at this station with the Camembert mold under varying conditions. Hundreds of these cheeses have shown repeatedly that cheese so made will assume in ripening the texture of the best imported article. The Camembert Penicillium, therefore, is seen to be able to neutralize the acid of the freshly made cheese and to produce the texture desired, but not the flavor. It remains to determine whether other molds may not be equally useful in this process. For comparison cheeses have been made and inoculated with the Roquefort Penicillium with undetermined species of Penicillium appearing on the record as O, 300, 310, 68, 132. Of these species one, 310, when cultivated upon every medium used except the cheese duplicated the reactions of the Camembert mold completely. Its morphology is scarcely distinguishable. It differs only in that it remains pure white during its entire cycle of development, while the Camembert species turns gray-green in age. The close relationship apparent, together with a promising test, led to its use upon over 100 cheeses. The breaking down resulting from its action was widely different. These cheeses were drier, waxy, with a mealy crumbling layer just under the rind. The physical character of the results and the flavor produced were so different that the

cheeses were entirely worthless. This mold was originally isolated from a market Camembert cheese, where it was found mixed with others.

The presence of the Roquefort Penicillium may be seen by the spots of green it produces and may be detected by a sharp, bitter, perhaps astringent, taste. The texture of the cheese produced is different, and the flavor when it is present in any large amount is so strong as to be very objectionable to many. When present in small amounts upon a cheese it gives a certain sharpness or piquancy to it, such as has been found often in certain brands of imported cheese, and is sought for by some buyers.

The species marked O and 300 secrete a bright yellow pigment into the cheese, which colors every area with which it comes in contact. A cheese was inoculated with No. 300 and examined when 8 weeks old. It had produced no trace of the texture of Camembert. The center of the cheese remained practically sour curd, while the portion for perhaps one-fourth of an inch under the colony was decomposed.

The species marked 68 has been obtained from cheese from widely different sources. In cultures upon milk and milk agar it produced little change. A cheese inoculated with it remained largely sour curd for two months. The species marked 132 is a very common green form, appearing in dairy and other cultures. It has given no satisfactory results when grown upon cheese. In this way related species found in cheese work have been tested in their effects upon cheese and shown not to produce digestion comparable in physical character to that demanded in a Camembert cheese and constantly obtained by the use of the Camembert Penicillium. There seems to be no further question that this species of Penicillium, among all the molds so far studied, is the only agent capable of producing the characteristic texture of the best type of Camembert cheese, with no objectionable flavors or colors.

FLAVORS.

All attempts to produce the flavor of Camembert cheese in pure cultures upon milk and curd with particular organisms have failed. Here again we have had to depend upon the use of cheeses so that direct, positive proofs have not been possible. The value of the indirect or circumstantial evidence offered must depend upon the completeness with which all factors have been considered. It has been previously shown that a cheese may be ripened to the texture of the best Camembert by the action of lactic bacteria and the Camembert Penicillium, but that it will lack flavor. A series of difficulties are met here. The typical flavor does not begin to appear until ripening is well along. This would indicate that the flavor-producing agent or agents must act upon already partially ripened cheese to produce the par-

ticular end products which give this flavor. But coincident with this change the acidity of the curd has become so far reduced that bacterial development may now occur on the surface at least, and as a matter of observation few cheeses begin to show flavor until cultures from their surface show swarms of bacteria of various species. It has not been practically possible to change these conditions sufficiently to make cheeses bearing only pure cultures upon the surface. The problem becomes, then, one of comparative study and the elimination of the unnecessary factors one by one, rather than the direct production of the flavor sought in a single conclusive experiment.

Some organism or organisms must be sought for to produce the flavor. The appearance of the flavor of the imported article in certain experimental cheeses at this stage of the investigation led to their immediate study. This showed that *Oidium lactis* was abundant upon these cheeses and emphasized the fact that it had always appeared in cultures from market cheeses. Oidium had been excluded from many experiments in cheese making because it had been found to be associated with odors that seemed undesirable, as well as because of the conclusion of Epstein from his researches, that the presence of Oidium is uniformly deleterious. The inoculation with spores of Oidium of a half-ripened cheese entirely lacking flavor produced the flavor distinctly in a single week, but since bacterial action seemed always associated with this, further evidence was necessary. Roger and Epstein have attributed the ripening of Camembert to the action of certain bacteria without distinguishing that the production of the texture of the cheese is accomplished by a different agent from the production of flavor. In their descriptions ripened Camembert is always referred to as slightly reddish in color, and the appearance of this color is regarded as an indication of the progress of ripening. In cheeses selected and forwarded by M. Roger this red color was very prominent and the red layer was found to consist of myriads of bacteria of a few species. Cultures from these cheeses showed that *Oidium lactis* was also present in abundance. Numerous tests have been made with the bacteria found associated with the various brands of Camembert cheese hitherto without producing the flavor in any case independently of the molds. The comparative study of many cheeses from the market and from our own cellars seems to show that cheeses may have the typical Camembert flavor without the development of any specific surface growth of bacteria. The character of the bacterial growth upon the surface appears, therefore, to be incidental or accidental, though its presence may be necessary to exclude air, as maintained by Mazé[9] in a recent paper.

Cheeses of good flavor have been produced here and also purchased in the market, which indicate that particular surface appearances are not essential to the typical flavor. Similarly the introduction into

new cheeses of species of bacteria found in cultures from the interior of good cheeses has produced either no effect whatever or disagreeable flavors. Thus far, therefore, no species of bacterium has been found capable of producing the Camembert flavor. Although the flavor question is manifestly still unsettled, we may offer the following summary of the data at hand upon relation of molds to flavor in Camembert cheese:

(1) *Oidium lactis* has been found in every brand of Camembert cheese studied.

(2) It has never been found upon a ripened Camembert cheese which lacked the flavor.

(3) The flavor has never been found in a cheese without the Oidium.

(4) Every other species with which the flavor seemed obtainable has been eliminated from one or more experiments without loss of flavor.

(5) Bacteria or other molds do in many cases modify the flavor of Camembert cheese, but do not seem to be able to produce it independently of the mold. There thus arise characteristic secondary flavors which are associated with the output of certain factories and which command special markets. These varieties are usually more highly flavored than what we have regarded as typical.

The essential relation of the Camembert Penicillium and *Oidium lactis* to the production of Camembert cheese is, therefore, well established. Several mycological questions remain: What are the optimum conditions of temperature and moisture for the use of these molds in cheese ripening? What are the most practicable means of cultivating material for inoculation? How can the proper inoculation with these molds be most effectually secured? What other fungi occur as contaminating species and how can they be controlled?

TEMPERATURE.

Since the higher temperatures of the ripening cellar lead more rapidly to the development of bacteria, it is necessary to determine the lowest temperature which will permit mold growth and also enzyme action. The different species respond quite differently to temperature. In one experiment eight species were inoculated into slanted tubes of gelatin and put in a refrigerator where the temperature varied from 5° to 10° C. Of these the Camembert Penicillium and two nearly related species, Nos. 68 and 310, grew, but fruited very slowly, showing an inhibiting effect. The Roquefort Penicillium grew and fruited normally, as also did *Oidium lactis*. The species of Mucor used developed very slowly and fruited only slightly. Two of the very common green species of Penicillium grew richly. *Oidium lactis* grows abundantly in the Brie and Isigny cellars visited. In these the temperature was 50° to 55° F. (11° to 12° C.). Numerous experiments in the ripening cellar show that the Camembert Penicil-

lium does not grow its best in a room cooler than 60° F. (15° C.), and that to obtain rapid development the room should be slightly warmer. Until this mold is well established, therefore, it is distinctly an advantage to grow it at a temperature of 65° to 70° F. Repeated experiments have shown that lowering the temperature to 52° to 55° F. checks the rate of ripening very materially. A difference of less than 10 degrees between two rooms will often make as much as two weeks' difference in the ripening period of cheeses from the same lot in the two rooms. A temperature as low as 54° to 55° F., as given in an article in the Creamery Journal previously referred to, appears to prolong the ripening period without contributing any compensating advantages. A half-ripened cheese was cut, the progress of the softening of the curd was noted, and the cheese put in a refrigerator, where it was held for four weeks at 48° F. It was then found to be completely ripened and perhaps a little old in one place, but the changes noted at the end of this period would have been produced within a single week at 60° F. The cold-storage possibilities suggested by this experiment will be further studied.

Some experiments were made to show the resistance of spores to heat. The spores of the Camembert and Roquefort Penicillia were inoculated into gelatin and placed in an incubator. Heating for an hour and fifteen minutes at 56° C. killed all spores of the Camembert species. Only a few spores of this mold grew after one hour at the same temperature, while some spores of the Roquefort Penicillium grew after two and one-half hours.

HUMIDITY.

The use of very moist cellars and caves in the ripening of this class of cheeses is practically universal. The richest development of mold is seen in rooms where the atmosphere is saturated or nearly so. This appears to be exceptionally true for species like the Camembert Penicillium, which is peculiarly a milk fungus, and in which there is a large development of thin-walled aerial mycelium. So dependent is the Camembert mold upon abundance of moisture that it has been found difficult to secure a rich growth upon the surface of a cheese which has been drained for two or three days before inoculation. Contrary to directions commonly given for ripening these cheeses, which call for a particular degree of humidity, cheeses have been ripened successfully in our cellars at the saturation point, as well as at various degrees of humidity below that. A good illustration of a mold which has adapted itself to changes of moisture is found in mold No. 198 Upon a fresh cheese in a moist room this mold forms a circular, ringlike colony of floccose hyphæ standing often 8 mm. high upon the surface of the cheese. In a drier situation, or when the cheese is nearly ripe and the rind becomes harder and dried, the same mold

produces conidiophores which barely rise above the substratum, so that the surface of the cheese is covered by a white, powdery layer which is practically pure spores. The Mucors are so sensitive to moisture that they scarcely develop upon the cheese, except sometimes during the first few days, when the surfaces are very wet. They appear to be unable to withstand the rate at which surface evaporation proceeds in the ripening cellars.

INOCULATING MATERIAL.

The problem of propagation of the Camembert Penicillium for inoculation purposes presents some difficulties. This species bears spores only upon the surface of the culture medium used, in contrast to the Roquefort species, which, when grown upon bread, develops spores in every air space, as well as on the surface. To produce spores in quantity, therefore, material must be capable of sterilization and must present the largest possible amount of free surface in proportion to the space occupied. For the preparation of such material, quart fruit jars have been used. Various styles of crackers have been tried. Most of these were not successful. The most suitable appears to be the hard, dry "water cracker." The jar is filled with crackers and dry sterilized at 140° to 160° C. for an hour or more, better twice on successive days. The spores may be added directly, or first inoculated into about 100 c. c. of sterile water (acidified with 1.5 per cent of lactic acid usually) and this poured into the jar and shaken until all the crackers are wet. Various types of "milk cracker" soften to a pasty mass in this moistening process. The best water crackers are not very satisfactory, because the mycelium tends to transform bread or cracker into a soft, gummy mass. The crackers become matted together until they present much less actual surface than might be expected. The substitutes tried have been excelsior, hay, and sheets of cardboard wetted with milk or whey. Although some of these have advantages, they were on the whole less satisfactory than the water crackers. So far, therefore, on account of the very different habit of our mold, no material has been found so easily prepared and so satisfactory as the "Schimmelbrot" of the Roquefort cheese makers.

From the point of view of the use of pure cultures the *Oidium lactis* is even more troublesome. This mold produces a large proportion, and in some strains all of its spores as chains below the surface of the substratum. For pure-culture work Petri-dish cultures have been the only satisfactory vessels used. Its exceedingly rapid development, however, makes possible the propagation of a culture from day to day from the draining boards upon which the cheese is made. These become heavily coated with a slimy mass of mycelium and spores upon standing overnight. Direct transfers from them have been used with apparently no serious trouble from contamination. In fact, so capa-

ble is the Oidium of self-propagation in dairy work that Epstein declares it to be present in all dairy work. Although Roger in his published statement does not mention it at all, it was found abundantly upon the cheese forwarded by him to this station. We have succeeded by careful work in making many cheeses entirely free from Oidium, but with the ordinary treatment of dairy utensils it appears constantly in factory practice. It is practically possible to rely to a considerable extent upon the ability of the Oidium to propagate itself, as has hitherto been done in the factories.

INOCULATION WITH PENICILLIUM.

With the Penicillium, however, numerous experiments indicate that there is much advantage in early and effective inoculation from cultures of known purity. Whether such inoculation must be always made from specially grown laboratory cultures is questionable. In factory practice, the making room and the ripening cellar are usually adjacent. If precautions are taken always to have on hand some cheeses bearing pure cultures (and the cheese maker must know his mold so well that there will be no question about it), one or two such cheeses will furnish enough inoculation material for much newly made product. This would be indicated by the rough calculation that from the abundance of the chains of fruit and the size of the spores (0.005 mm. in diameter) probably about enough spores are produced to cover evenly the surface upon which they grow—perhaps 25,000,000 to the square inch. Very successful inoculation in 75 pounds of milk has commonly been secured by tapping a Petri-dish culture over the vat, or by breaking a piece of cracker about an inch square or less and stirring it into the milk.

The most economical and successful method of inoculation so far devised has been the use of a sprinkling jar or can. For this purpose holes 1 mm. or less in diameter in the jar lid are demanded. A small amount of water is put into the jar, a piece of cracker or cheese covered with mold is broken into the water, the top is then screwed on, and the jar thoroughly shaken. The water is then sprinkled upon the newly made cheese at the time of first turning, so that both sides of each cheese receive a few drops of water. Excellent results have been obtained in this way with the smallest amount of inoculating material and the least requirement of labor and skill. Such a jar should be emptied and washed immediately after using. The mixture is made fresh each time. Milk may be used instead of water, as was first suggested and tried by Doctor Conn; but the water has been found the more easily managed. The practical method for factory use will probably vary with the conditions and skill of the maker.

VITALITY OF SPORES.

Studies have been made upon the vitality of the spores of the species used. This varies greatly in different species. In some of the most common forms spores have been reputed to remain viable for several years. Recent studies by Wehmer showed that five species of Penicillium used in his experiment were entirely dead in laboratory cultures at the end of two and one-half years. Cultures of the Camembert Penicillium grown upon potato in test tubes plugged with cotton have refused entirely to germinate at the age of one year. Other cultures have seemed entirely dead inside of six months. In fact, the spores of this mold are very thin walled and die very rapidly when stored. Under such conditions they lose turgidity and become crenulated or indented. Spores of *Monilia candida* and several others have grown after more than a year in laboratory cultures, but their germination was much retarded. *Oidium lactis* seems to be very easily killed by drying, as would be expected from a species with such thin-walled spores. The Roquefort Penicillium under some conditions is more resistant, but loses vitality quite rapidly. It is certain, therefore, that to give the best results material for inoculation should be fresh and vigorous. Under ordinary circumstances it would not be desirable to use material more than a few weeks old.

CONTAMINATIONS.

The number of molds found upon market Camembert cheese shows the need of care in guarding against contamination of cultures. Extraneous molds may come from the milk or from the utensils used or from the clothes and hands of the workmen. Although the milk is the primary source of most infections, practical experiments have shown that if the proper molds are put upon the cheese at the time of making the troubles arising in this way may be minimized. In fact, sufficient contamination from this source directly to ruin a cheese is very uncommon.

The very habit in some countries of washing or rinsing cheese-making utensils in whey will account readily for the universal presence of *Oidium lactis* and perhaps for many of the bacterial infections that result in loss. But the source of the most trouble in a cheese cellar is found to be the cheese maker himself. The cheeses are commonly exposed upon curing boards and turned and examined in the hands. In this way spores from molds or bacteria occurring accidentally as single colonies upon single cheeses are distributed by thousands to hundreds of cheeses. The product of a factory may almost be identified in the markets by the contaminations upon the surface of its cheeses. Certain brands of the cheese always bear *Monilia candida* and commonly one or two other Monilias. A species of Fusarium is distinctive of another brand, with *Acrostalagmus cinnabarinus* occa-

sionally present. After numerous experiences with all sorts of contamination this trouble has been practically eliminated from our experimental work by putting the fresh cheeses, as soon as they are drained, salted, and comparatively dry upon the surface, into boxes which are slightly larger than the cheeses, leaving air space and room for mold to develop normally. In this way fingering is done away with, the cheese is turned by turning the box, and examined by removing the lid without touching the surface, so that a colony of mold appearing upon one cheese is no longer distributed throughout the cellar.

It is therefore possible to produce cheeses practically free from molds other than those inoculated upon their surface. Although such boxing upon a large scale may be practically undesirable on account of expense, it remains certain that it may be useful in eliminating certain troubles without so large a loss as would come from discarding all infected cheeses, many of which would ripen satisfactorily but for the danger of spreading obnoxious fungi over great numbers of cheeses.

ROQUEFORT CHEESE.

The well-known Roquefort cheese is another highly flavored cheese in which mold has long been known to play a part. In manufacture this cheese approaches the hard type, but the ripened cheese bears a closer relation to the soft cheeses. Many complete descriptions give the details of its making and curing. These need not be repeated here. Roquefort is by description a goat's or sheep's milk cheese, made in France principally, though cheese of nearly the same quality is said to be made in other parts of Europe from mixed cow's and sheep's milk or from cow's milk alone.

The great popularity of Roquefort cheese makes information as to the biology of its ripening processes very desirable. To this end numerous specimens of Roquefort have been purchased and analyzed. The results of this work have been very much simpler than the studies of Camembert. The ordinary Roquefort cheese before it is sent to the market is carefully cleaned and covered with tin foil. Its surface would, therefore, tell very little. When cut it is seen to be traversed by channels or ho es made by the prickle machine (Stechmaschine) and by cracks. Every air space is lined with green Penicillium, so that the cut surface is said to be marbled with green. The texture of the cheese is reasonably uniform, with every indication that ripening is simultaneous throughout the cheese or at least approximately so. Its texture is rather crumbling than waxy, with a tendency to dissolve readily in the mouth. The taste is a characteristic sharp flavor, in which a rather high salt content is noticeable. Its odor is strong, cheesy rather than offensive in any way, except as pronounced

putrefactive odors are sometimes developed in the rind. Cultures from the surface often show various species of fungi. There is no regularity about the surface, however, while uniformity of texture and appearance is universal on the inside. Cultures from the interior show a remarkable uniformity. In many cheeses examined a pure culture of a single species of Penicillium has been found. The extremely rare appearance of any other mold in the cultures has been remarkab e. Similarly the bacterial content is usually limited to typical lactic forms. Sufficient analyses have been made to establish clearly that a first-class Roquefort cheese should conta n only lact c bacteria and the Roquefort Penicillium. This Penicillium is often referred to by writers as *P. glaucum* and regarded as the common green species, but as it has very characteristic morphological and physiological characters it seems best to designate it as the Roquefort Penicillium, even though it quite often occurs upon other substrata.

The cultures which have been conducted in connection with the study of Camembert cheese have shown that the Roquefort Penicillium is capable of digesting curd very completely. Here, as in Camembert cheese, chemical analyses have shown that the derivatives of casein become almost completely water soluble. Further pure-culture experiments upon sterile curd have shown that this mold during the process of digestion produces bitter flavors during the first few weeks, but that its continued action changes these to typical flavors of the Roquefort cheese. Here, then, we have a definite, positive result. It is thus shown that the Roquefort Penicillium, acting with the lactic bacteria, is capable of ripening Roquefort cheese without the introduction of other enzyme-producing or flavor-producing organisms. The investigations of the chemical nature of these changes have barely been touched upon at this time. In a recent experiment a cheese of the Roquefort type was made of cow's milk inoculated with the Roquefort Penicillium and kept in a room at a temperature of about 60° F. At the end of five weeks this cheese was found to have acquired both the texture and the flavor of genuine Roquefort. There seems to be no doubt that it will be possible to develop methods of making and ripening that will produce the Roquefort type of cheese successfully in the United States. Details of making and handling will then be offered.

CHEESES RELATED TO ROQUEFORT.

Single studies have been made from the Italian Gorgonzola, English Stilton, and Hungarian Brinse (Brindze or Brimse). Gorgonzola and Stilton are made from cow's milk. Brinse is described as made from sheep's milk, mixed sometimes with goat's milk. These three varieties of cheese are found marbled with green Penicillia in pure cultures, which are unquestionably one or more strains of the Roque-

fort Penicillium. In the Gorgonzola and Stilton cheeses examined lactic species were the only bacteria found. Comparison of the flavors in these cheeses shows that the differences lie in the qualities of the materials used in the making and the handling of the cheeses rather than in the qualities attributable to ripening organisms. It is peculiarly interesting to find the same species of mold in the interior of ripened cheese in four countries so widely separated, where no efforts at the use of pure cultures are known to be made. Experiments show that in every locality so far studied there are many green species of Penicillium. It is evident, then, that the food material or the conditions, or both, presented by these types of cheese must exert a selective influence upon the molds, which results in the dominance of the one species so universally found. This species has been introduced into experimental cheeses at this station.

AMERICAN BRIE AND ISIGNY.

Cheeses of the type referred to in our previous bulletin as the American Brie have been studied for comparison. This was a collective term suggested to cover cheese sold under various labels as Brie, Isigny, Wiener, Miniature, and others, designated commonly by the retailer simply as Brie. The name "Brie" seems to be applied in the French dairy literature to a cheese which differs from the Camembert in the process of making, but ripened by the same fungi and approximately in the same way as Camembert. The domestic product so far as examined is quite different, with the exception of the output of one factory, which is conducted by imported cheese makers. The cheese met in the eastern markets under these names shows no trace of the Camembert Penicillium. Numerous brands have been examined in the market and many hundreds of cheeses have been seen in the cellars of two of the largest cheese companies. *Oidium lactis* is universally present upon these cheeses, but its presence goes practically unnoticed by the makers, since it produces neither color nor aerial mycelium. All noticeable molds are washed or scraped from the surface of the cheese. The washing produces exactly the best conditions for the growth of bacteria and Oidium. This treatment results in a cheese without a very definite fungous rind and with a strong flavor and smell.

Cultures from this type of cheese indicate that there is an associative action between the *Oidium lactis* and various species of bacteria. Several species of Penicillium occur as contaminations in these cellars and sometimes are found upon the cheeses in the market. Every effort is made to eliminate mold action other than that of *Oidium lactis*, which usually passes unrecognized. Cheeses of this type usually bear rich growths of yeasts, giving a characteristic greasy feeling to the surface. Exactly what parts these various organisms play in the production of Brie is as yet undetermined.

Single studies have shown that *Oidium lactis* is the dominant mold upon the surface of some brands of Limburger, brick, and Port du Salut. There is, then, good reason to believe that this fungus is associated with nearly every type of highly flavored, ripened soft cheese met in the American market.

MOLDS REFERRED TO IN THIS PAPER.

The Camembert and Roquefort molds belong to the hyphomycete genus Penicillium, which has been characterized by one author—

Hyphæ broadly effused, creeping; conidiophore branched at the apex in an irregularly verticillate manner, producing brush or broom-like forms; conidia in chains, hyaline or bright colored, spherical or elliptical.

This genus of fungi contains a large number of very poorly described forms which are everywhere abundant as the "green" or "blue" mold of the household, the dairy, and the granary. They form patches upon and just under the surface of the materials upon which they grow. The patches are composed of delicate threads of mold, which are matted together, forming more or less cottony surfaces, never rising more than a small fraction of an inch above the substratum. At first these areas are always white, but in most species the ripening of a crop of spores is indicated by the change to a color which is usually some shade of green, though this may later give place to a brown. In a few species other colors appear. These spores (conidia), or propagating bodies, are minute thin-walled cells averaging possibly one five-thousandth of an inch in diameter, and so light that they float freely in the air. A breath upon the surface of such a colony carries away thousands of them, when if held in a proper position they may commonly be seen to rise in a cloud. If the colony be held to the nose and inhaled they give the sensation commonly called the "smell of mold." They are, then, exceedingly light; they are produced in immense numbers; they are capable of growing in almost every conceivable situation, upon anything which is not definitely and strongly poisonous. Some of these spores are short lived, others cling tenaciously to their power to germinate. Of the species, probably a dozen common ones may be expected in any locality, perhaps more. Our studies have shown that they affect very differently the substances upon which they grow. It is, then, clearly necessary that by thorough study of their characters and habits we know the forms we are to use, and just as important that we know how to get rid and stay rid, if it be possible, of those we do not want. The discussion of the whole group will be reserved for another paper. Here we may describe in simple terms the two cheese fungi we find important, but it may as well be acknowledged at the outset that, with the possible exception of the Camembert species, safe recognition of species without technical knowledge and cultural study is out of the question.

THE CAMEMBERT MOLD (PENICILLIUM CAMEMBERTI).

The spores of the Camembert mold grow rather slowly in comparison with the other molds of the group. They first swell to nearly double size, and then produce fine threads or hyphæ at from one to three points on their surface. Upon a cheese or in laboratory culture the subsequent growth of these threads forms a colony large enough to be visible to the naked eye, in ordinary room temperature, in about two days. Usually in four or five days the colony will have become loosely white, cottony, about one-half inch or less in diameter, and perhaps standing one-twentieth of an inch above the surrounding surface. At or about this stage the center of this colony begins to turn a shade of greenish gray, which is characteristic of this species, though one or two other forms produce colors closely resembling this shade, and difficult to distinguish from it except to one very familiar with the colors in question. This is due to the presence of ripe spores. Upon the cheese in the cellar this color often does not appear in less than a week or even ten days. Microscopic examination shows that the submerged threads of mycelium of such a colony do not go deeper into the solid media than one-sixteenth of an inch, and that the superficial portion of the mycelium spreads as fast, or nearly so, as the part beneath the surface of the substratum. This fungus grows and fruits for about two weeks—in some cases this may be prolonged to three weeks—and at the end of that period no further growth is to be expected from the primary colonies, nor, if the medium is undisturbed, is there a secondary growth from the germination of the spores produced by the first colony. In case the rind of the cheese is broken so that a fresh surface is presented, the spores will develop new colonies upon such areas. A colony, then, produces a single crop of spores and dies, under ordinary circumstances, and in undisturbed cultures there is usually no second growth from the spores or from the old mycelium, although the contrary has been claimed for this fungus by a recent writer (Mazé [9]). A cheese inoculated with this mold will become

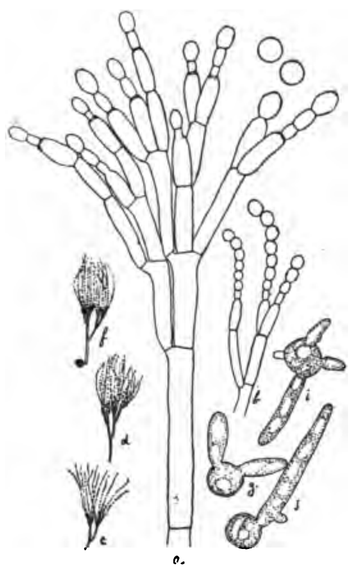

FIG. 1.—Camembert Penicillium (*P. camemberti*). *a*, conidiophore showing a common type of branching and the production of basidia and conidia, highly magnified; *b*, a common form showing much less branching; *c*, *d*, *f*, diagrams of large fructifications (× 80); *g*, *i*, *j*, germinating conidia.

covered with pure white cottony mycelium in about a week. The color will then begin to show the gray-green shade characteristic of the species, which spreads, until at the end of the second week the entire surface, if left undisturbed, will be colored.

Persistent search has failed to find a single colony in America whose presence can be attributed to anything but Camembert cheese imported from Europe. The mold may then be regarded as a typical dairy form which is not well adapted to cosmopolitan conditions and to the struggle for existence on all sorts of media. In fact, in the course of laboratory practice involving thousands of cultures, even in the laboratories of this station, this mold rarely appears as a contamination, although it has been cultivated in quantity and used in the inoculation of large numbers of cheeses in the same building with the bacteriological laboratory. Moreover, the spores are easily killed by heat and retain their vitality for only a few weeks in ordinary cultures allowed to dry in the air at room temperature.

TECHNICAL CHARACTERIZATION OF THE CAMEMBERT MOLD.[a]

The following technical characterization of *Penicillium camemberti* (fig. 1) may be offered, based upon studies made upon the sugar gelatin and potato agar described in this paper:

Colonies effused, white, slowly changing to gray-green (glaucous); surface of colony floccose, of loosely felted hyphæ about 5 μ in diameter; reverse of colony yellowish white; conidiophores 300 to 800 μ in length, 3 to 4 μ in diameter, septate, cells thin-walled, often collapsing in age, arising as branches of aerial hyphæ; fructification sometimes 175 μ in length, but usually much less, consisting commonly of one main branch and one lateral sparingly branched to produce rather few basidia, which bear long, loosely divergent chains of conidia. Basidia 8 to 11 by 2.4 to 3 μ; conidia at first cylindrical, then elliptical, and finally globose when ripe, smooth, bluish-green by transmitted light, thin-walled and commonly guttulate, 4.5 to 5.5 μ in diameter, swelling in germination to 8 to 10 μ. Germtubes one to several. Cells of mycelium about 5 by 20 to 40 μ; liquefies sugar gelatin only under the center of the colony. Changes blue litmus to red strongly at first, then after four to six days begins to turn the red back to blue at the center and continues outward concentrically until all has become blue. Growing and fruiting period about two weeks. Fruits only upon exposed surfaces of the substrata—never produces spores in cavities not very broadly open. Habitat, cheese.

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[a] *Penicillium camemberti* (nomen novum). This species is unquestionably the one referred to by Mazé in his recent papers as *P. album* Epstein. Professor Mazé was kind enough to show me the cultures. But the name *P. album* was already used by Preuss some fifty years earlier for a species of Penicillium, hence by the rules of nomenclature should not be used again for a species whose identity with *P. album* Preuss is not claimed by Epstein. Upon this ground Lindau, in Rabenhorst's Kryptogamenflora, has changed the name of Epstein's fungus to *P. epsteini* Lindau, and extracted from the article written by Epstein a brief and totally insufficient diagnosis. A careful study of the physiological data given by Epstein shows that they differ from the data so far found for this species so materially as to lead to the probability that he was studying another form entirely. I therefore give *P. album* Epstein in the list of possible synonymy only, because the name is accepted by Mazé for what I know to be this species.

THE ROQUEFORT MOLD (PENICILLIUM ROQUEFORTI).

The spores of the Roquefort mold grow very rapidly, often producing new mycelium and ripe spores within thirty-six hours. The colonies are white at the very first, but begin to become green at the center within two days in a rapidly growing colony. Such a colony may become a half inch in diameter in the first two days. The mycelium is mostly submerged, but very close to the surface, and grows rapidly outward from the starting point in a radial manner, which is rendered prominent by certain of the threads lying just under the surface for the most part, but making loops into the air by rising just above the substratum for a little way, then reentering the medium again. This gives a grayish, almost cobwebby (arachnoid), appearance to the margin of the young colony. The rate of growth is not uniform in the circumference of such a colony, which makes the border of a colony uneven instead of regularly circular, as most species appear. The superficial portion of the Roquefort mold is almost entirely composed of the fruiting hyphæ or conidiophores, the vast majority of which arise as branches of submerged hyphæ and consequently stand separately as short, unbranched threads of approximately equal length, which gives the surface a velvety appearance. They are usually 0.2 or 0.3 mm. or less in length, say one seventy-fifth of an inch. Such a colony spreads indefinitely in the substratum, so that the center will be composed of ripe fruit, while the margin is still actively growing. In laboratory culture, however, the development is so rapid that the entire surface is covered within the first few days; then growth ceases. The mycelium here, as in the Camembert mold, produces but a single crop of spores, then dies. These spores are a bright green at first, but in a short time become a dirty-brown color in dry culture. The spores of this fungus are much more resistant than those of the Camembert mold both to heat and to natural exposures. They will retain their viability for months in old cultures under the ordinary conditions of exposure in the laboratory. Upon a cheese this mold produces a bright green area which extends rapidly. Its action can be detected in a few days by the bitter taste of the curd near to the mycelium. A similar taste is, however, produced at least in some measure by other green forms, so that it is not diagnostic except as between this and the Camembert species. A colony upon the surface of a cheese becomes brown in two or three weeks, but colonies growing in the cavities which are so characteristic of the center of this type of cheese retain their bright green color for long periods.

This mold is not limited to dairy products, but is widely distributed. It has been sent to the laboratory from the most distant correspondents. It has been found in silage, and in laboratory cultures from many substances. It has been found to be the green mold of Stilton, Gorgonzola, and Brinse, as well as in certain types of prepared cheese

purchased in the market. Once in a laboratory it stays and seems to get into everything. In other words, this is one of the cosmopolitan and omnivorous species of the genus. One character seems to differentiate this mold from most of the others—that is, its power of growing into and fruiting normally within narrow cavities, such as appear in cheese. It appears that this character exerts a sort of automatic (perhaps we may call it a truly "natural") selection which eliminates all other species from the ripening processes of Roquefort and related types of cheese.

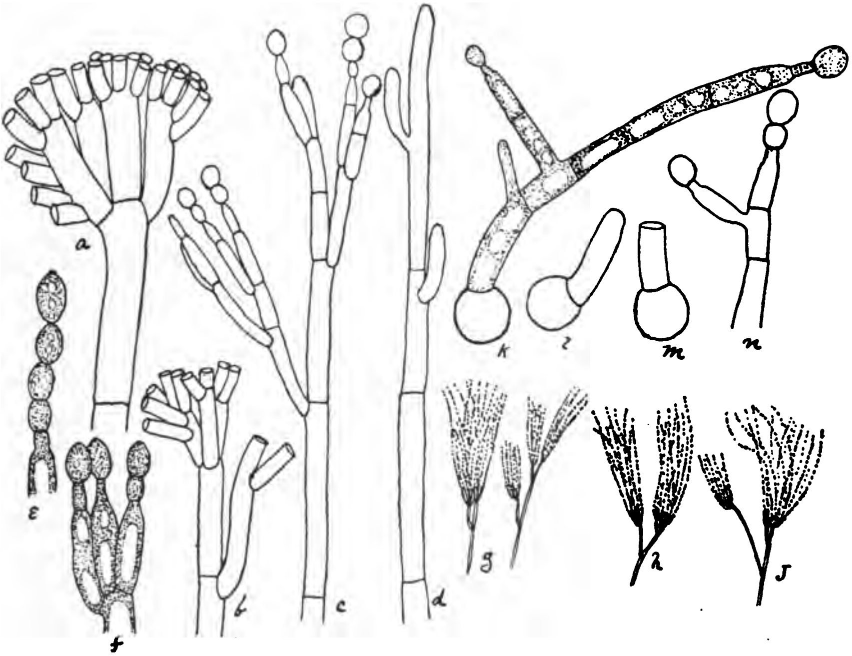

FIG. 2.—Roquefort Penicillium (*P. roqueforti*). *a*, part of conidiophore and of bas of fructification, highly magnified, showing the production of basidia on the sides as well as at the apex of the basidiophore; *b*, *c*, other types of branching; *d*, young conidiophore just branching; *e*, *f*, basidia and the formation of conidia, highly magnified; *g*, *h*, *j*, diagrams of types of fructification as seen under low power (× 80); *k*, *l*, *m*, *n*, germination of conidia and new conidia produced directly on the first hyphæ.

TECHNICAL CHARACTERIZATION OF THE ROQUEFORT MOLD.[a]

A technical characterization is offered of *Penicillium roqueforti* (fig. 2), as follows:

Colonies quickly turning green, becoming a dirty brown in age, velvety strict, indeterminately spreading by large main radiating, branching hyphæ, giving a somewhat uneven or

[a] *Penicillium roqueforti* (nomen novum). In offering a new specific name for this well-known fungus, the author is perfectly aware that the mold is often referred to in the literature as *P. glaucum*. A careful study of the literature fails to disclose a single description which indicates that this is identical with the plant described as *P. glaucum*. As a preliminary step, therefore, to the proper determination of the green species of Penicillium which have hitherto been collectively referred to as *P. glaucum*, this very distinct and easily recognized form is named from its universal occurrence *P. roqueforti*.

indefinite margin, which gets a white, fibrous, almost spider-web appearance from its alternation of submerged parts of hyphæ with short prostrate aerial loops; reverse of colony yellowish white. Conidiophores arising separately and in acropetal succession from the growing parts of submerged hyphæ (comparatively few from aerial parts, but some), 200 to 300 μ septate. Fructification 90 to 120 μ or at times 160 μ by 30 to 60 μ at broadest place, usually appearing double by the divergence of the lowest branch; branchlets (basidiophores) irregularly verticillate, bearing crowded verticils of appressed basidia 9 to 11 μ by 2.5 μ with long divergent chains of conidia. Conidia bluish green, cylindrical to globose, smooth, rather firm-walled, 4 to 5 μ in diameter, germinating by a straight tube. Colonies do not liquefy sugar gelatin, though they soften it somewhat. The fungus changes litmus from red to blue very rapidly and strongly, almost from the beginning of growth. Fruiting period short, but one crop of spores upon the mycelium. Cosmopolitan and omnivorous, or nearly so. Characteristic of Roquefort and related types of cheese.

OIDIUM LACTIS.

The mold (fig. 3) variously known as *Oïdium*, or *Oöspera, lactis* is another cosmopolitan organism. This fungus differs widely from the species previously described. Inoculated into any suitable medium it grows with enormous rapidity. A single spore (or oidium) may give rise to several centimeters of mycelium and hundreds of spores in twenty-four hours. It prefers very moist situations, since almost the entire mycelium is developed below the surface of the substratum. It is therefore passed unnoticed many times or produces changes which are attributed by the observer to bacteria. Description, therefore, must depend upon microscopic characters. The study of the border of the young colony shows numerous vegetative hyphæ radiating outward. Each of these is found to divide dichotomously (fig. 3, *a*, *b*), so that the border is a crowded series of forking branches. In the older parts of the mycelium a branch may be produced at each end of every cell, or several at each end, and these branch indefinitely. The fruiting branches are mostly produced as outgrowths from the distal ends of the cells. These extend upward into the air or remain entirely submerged in many cases. From the ends of these outgrowths one to several rows of oblong or cylindrical cells begin to be pinched off. If extending above the surface this gives rise to chains of delicate shimmering cells appearing as a powdery covering upon the surface, which can be seen with a good lens to be arranged in chains. In some strains of Oidium all of these chains (and some of the chains in all strains) of spores remain submerged and germinate at once, so that they give rise to unintelligible mats of hyphæ. Oidium produces a very slight acid reaction to litmus at first, then a strong and continued alkaline reaction. It liquefies sugar gelatin under the colonies, but does not extend the area of liquefaction beyond the edge of the colony. Oidium always and everywhere tested has produced a strong and very characteristic odor. Once familiar with this odor the worker may recognize its presence by its spores or oidia, which are hyaline,

smooth, cylindrical, 3.5 to 5 μ by 6 to 30 μ, varying with the conditions and the substratum and perhaps at times exceeding these limits. These swell variously and germinate in many ways, so that no germination characters are definite. Upon some media this mold may be induced to produce a large growth of aerial mycelium, but the limits here defined will include the variations to be found upon the usual culture media.

Oidium lactis is described as universally present on milk and its products. Epstein even suggests that experiments upon milk and cheese can not be freed from its presence without sterilizing. The

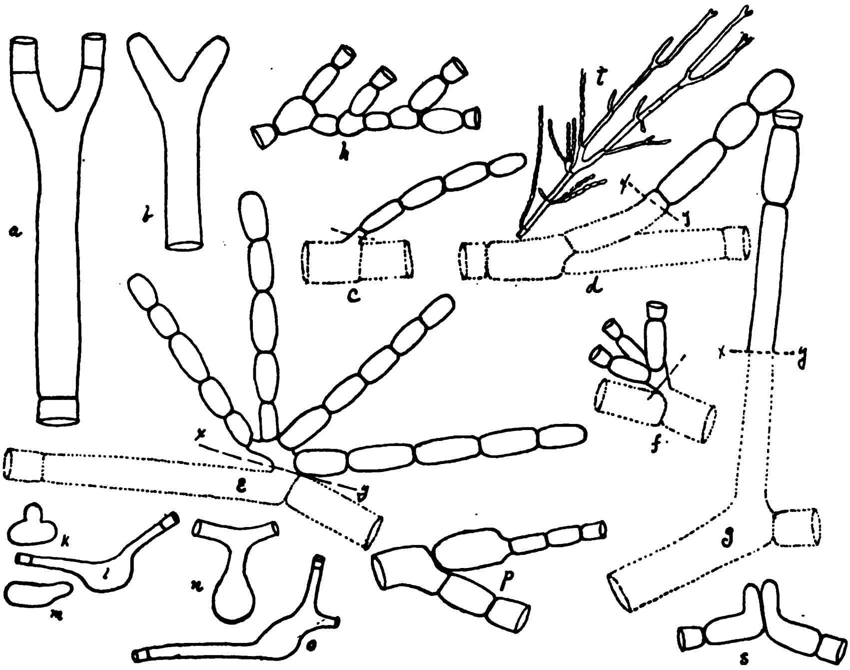

FIG. 3.—*Oidium lactis.* *a, b,* dichotomous branching of growing hyphæ; *c, d, g,* simple chains of oidia breaking through substratum at dotted line *x–y,* dotted portions submerged; *e, f,* chains of oidia from a branching outgrowth of a submerged cell; *h,* branching chain of oidia; *k, l, m, n, o, p, s,* types of germination of oidia under varying conditions; *t,* diagram of a portion of a colony showing habit of *Oidium lactis* as seen in culture media.

same or almost indistinguishable forms are found upon decaying vegetables and fruits, which may give reason for the statement that the odor produced by Oidium is that of rotten cabbage. There seems to be good reason for saying that all these forms are but varieties or strains of the same species. Comparison of several of them shows that under uniform conditions the morphology of all these forms is very nearly the same. This is largely true also of their physiological effects. This mold has been much studied and numerous papers discuss its nature and physiological effects as well as its relationships.

It will be sufficient to describe here the fungus and to give figures to assist in its recognition. Its relations to the problems of cheese ripening have already been indicated.

SUMMARY.

CAMEMBERT CHEESE.

The acidity of the curd resulting from the action of lactic organisms reduces where it does not entirely eliminate the growth of objectionable bacteria.

Many species of dairy fungi exert in the course of their development the power of changing this reaction to alkaline. The Camembert Penicillium and *Oidium lactis* possess this power, but not in greater degree than many other species.

Many species of fungi possess the ability to change curd to a greater or less extent.

The breaking down of curd by fungi is due in the cases studied to the production of enzymes.

The texture, appearance, and flavor of curd acted upon by such fungi are different for different species.

The Camembert Penicillium (*P. camemberti*) is the only species so far studied with which the particular appearance and texture sought in the ripened Camembert can be produced from curd soured by lactic bacteria without producing any objectionable flavor.

Oidium lactis is always found upon Camembert cheese and so closely associated with the presence of the flavor as to indicate its agency in flavor production, though only circumstantial proof of such function has been possible thus far. The participation of bacteria in flavor production is not excluded by these results.

Other species of fungi have been shown to produce variations in this flavor such as have been often found in certain market cheeses. In this way it is possible to look for the cause of differences in flavor in contamination of the cultures upon the cheeses. This points toward the use of pure cultures for inoculation, with the addition of special organisms if certain variations from what we have regarded as typical flavor are found to be of value in the market rather than dependence upon accidental occurrence of the desired species in the factory.

ROQUEFORT CHEESE.

In the ripening of Roquefort cheese the only organisms found necessary are lactic bacteria and the Roquefort species of Penicillium.

The Roquefort Penicillium has been shown to possess the power to reduce the acidity, to digest the curd, and to produce the typical flavor.

OTHER VARIETIES OF CHEESE.

The Roquefort species of Penicillium is found in the imported Stilton, Gorgonzola, and Brinse, as well as in Roquefort cheese.

Oidium lactis alone of the forms studied has been found upon the various brands of Limburger, Brie (American type), Isigny, and related cheeses found in the market. Other species incidentally occur, but not uniformly, and such occurrence is avoided as far as possible by the makers.

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O

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY.—BULLETIN No. 83.

A. D. MELVIN, CHIEF OF BUREAU.

THE COLD STORAGE OF CHEESE.

(EXPERIMENTS OF 1903-4.)

BY

CLARENCE B. LANE, B. S.,

Assistant Chief of the Dairy Division, Bureau of Animal Industry.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1906.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., March 28, 1906.

Sir: I have the honor to transmit the accompanying paper entitled "The Cold Storage of Cheese," being a study of this subject under commercial conditions with a view to solving some of the practical problems involved in this important branch of our trade.

This work, which was carried out during 1903–4, was planned and directed by the late Henry E. Alvord while chief of the Dairy Division of this Bureau. The results have been brought together and prepared for publication by Clarence B. Lane, assistant chief of the Dairy Division. The author gives credit to Duncan Stuart, assistant in dairying, for valuable aid in compiling tables and charts.

This article contains information which is believed to have considerable value for the cheese trade, and I therefore recommend its publication as Bulletin No. 83 in the series of this Bureau.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE COLD STORAGE OF CHEESE.

INTRODUCTION.

This experiment was planned and conducted by Maj. Henry E. Alvord, late chief of the Dairy Division, and it was practically completed before his death, which occurred October 1, 1904. The results have been brought together and tabulated by the writer in the present bulletin. The general details of the experiment were in charge of William E. Smith, dairy inspector, who was also chairman of the board of scorers. The other judges were B. F. Van Valkenburgh, dairy inspector, and F. P. Swift, representing one of the largest cheese-exporting firms in Montreal and New York. New York was chosen as the place for the investigations, and suitable arrangements were made at a cold-storage warehouse, where rooms were fitted up and the desired temperatures secured.

OBJECT OF THE EXPERIMENT.

The investigations were undertaken to study on a commercial scale and under commercial conditions the influence which different temperatures exert (1) upon the weight of the cheese, (2) upon the quality of the cheese, and (3) the influence of such temperatures in combination with coating the cheese with paraffin. The commercial quality of the stored product was determined by a jury of experts thoroughly in touch with the demands of the market.

PLAN OF THE EXPERIMENT.

About 3 tons of cheese was purchased, of three different types, or sizes, known in the trade as Cheddars, Flats, and Young Americas. The product was as even and uniform in all respects as possible, except for the difference in size and shape of the three types. About one-half of the cheeses were paraffined and the other half remained in their natural condition. Almost the entire quantity was divided into three lots, as evenly as possible in all respects, and these lots were stored at the temperatures of 28°, 34°, and 40° F., respectively. Each contained about 40 or 50 cheeses. The cheeses were examined by a committee of experts and weighed when first placed in storage and every

two months thereafter for a period of eight months. It was further planned to freeze another lot of cheese, much smaller than the lots mentioned above, holding this at a temperature of about 5° F., for the purpose of determining the effect of freezing on the quality. Chemical analyses were made of the cheese before placing in storage to determine its character.

SOURCE, CHARACTER, AND AMOUNT OF THE CHEESE USED.

The cheese selected was all of the firm typical Cheddar variety, made in the States of New York and Wisconsin. For convenience, we will group the lots as follows: Group I—Export Cheddar: *a*, natural; *b*, paraffined. Group II—Flats: *a*, natural; *b*, paraffined. Group III—Young Americas: *a*, natural; *b*, paraffined. Group IV—All the above-named styles, stored at freezing temperature.

The table herewith gives the locations of the factories from which the different lots were secured, and also the size, amount, and score of the cheese purchased.

TABLE I.—*Origin, quantities, and description of cheese used in the experiment.*

Origin and style.	Number.	Weight. Lbs.	Weight. ozs.	Flavor.	Make.	Texture.
Group I, Export Cheddar, Fish Creek Factory, St. Lawrence County, N. Y.	51	3,472	1	Almost perfection.	Fine, close, firm.	Waxy and mellow.
Group II, Flat, Springbrook Factory, Cattaraugus County, N. Y.	51	1,922	12	Fine to perfect.	Fine, close, firm.	Firm, mellow.
Group III, Young America, Valley House Factory, Sheboygan County, Wis.	40	415	11	Fine to perfect.	Firm, close, fairly waxy.	Firm, mellow, waxy.

Origin and style.	Color.	Style, finish.	Surfaces.	Boxing.	Paraffining.
Group I, Export Cheddar, Fish Creek Factory, St. Lawrence County, N. Y.	High, uniform.	Fine..	Smooth, firm, tendency to mold.	Good .	Well done.
Group II, Flat, Springbrook Factory, Cattaraugus County, N. Y.	High to very high, a few mottled.	Fine..	Bright, smooth, firm.	Good .	Well done.
Group III, Young America, Valley House Factory, Sheboygan County, Wis.	Good	Fine..	Bright, smooth, firm.	Good .	Well done.

The cheese was not made specially for this experiment, but was selected from the lots received in New York City from the above-named factories in the regular course of business, and the effort was made to select cheese that was of uniformly high quality.

CHEMICAL ANALYSIS OF THE CHEESE.

A complete chemical analysis was made by the Bureau of Chemistry of two of the styles of cheese (export Cheddars and Flats) in order to determine more accurately their exact character. As these two kinds came from different counties and represent two sections of the State of New York, the results are of interest. They are as follows:

SECTIONS OF CHEDDAR CHEESE BEFORE STORAGE.
[Lower figure shows small section of above cheese at natural size.]

TABLE II.—*Chemical analysis of export Cheddars and Flats.*

Style.	Water.	Fat, by official gravity method.	Fat, by Babcock method.	Approximate casein (N × 6.37).[a]	Ash.	Total.
Export Cheddar	37.76	32.64	Lost.	24.91	3.31	98.62
Flat	34.51	35.73	36.50	24.25	3.76	98.25

[a] Factor 6.37 is not correct for the nitrogenous matter of a ripened cheese; some of the chief products of ripening call for a larger factor, but in the present state of knowledge we can do no better than use the casein factor 6.37.

TEMPERATURES AT WHICH THE CHEESE WAS STORED.

The cheese was weighed and put in the storage rooms in boxes about two weeks from the time it was made, this being about the usual shipping age of cheese in commercial practice. The temperatures of 28°, 34°, and 40° F. were selected for the reason that the best storage temperatures were believed to range between 28° and 40° F. With any temperature below 28° F. there would be danger of freezing, and on the other hand it has been proved quite conclusively that cheese can not be carried in the best condition at a temperature over 40° F. As a part of the experiment some of the cheese was held at a temperature of 5° F. to note the effect of freezing.

The following is a copy of the score card adopted for the experiments:

[Experiments in storing cheese at low temperatures, United States Department of Agriculture, Bureau of Animal Industry, Dairy Division.]

CHEESE JUDGING.

NUMERICAL AND DESCRIPTIVE SCORE CARD.

Score for cheese (or sample) marked:..

NUMERICAL SCORE.

Perfection, 100 points.	Make, texture, body, 50 points.	Flavor, 25 points.	Color, 15 points.	Finish, surfaces, 10 points.
Score	....	....	....	....

Date:.................................., 190 . *Initials of judge:*................................

DESCRIPTIVE SCORE. (Check as found below.)

Make, texture, and body.		Flavor.	Color.	Finish, surfaces.
Perfect	Silky	Perfect	Perfect	Perfect.
Smooth	Rough	Clean	High	Fine.
Pasty	Stiff	Flat	Medium	Good.
Weak	Acidity	Fruity	Light	Poor.
Sour	Close	Sweet	Spotted	Checked.
Loose		Tainted	Streaked	Damaged.
Holes, mechanical		Weedy	Mottled	
Holes, gas		Tallowy	Natural	

LENGTH OF THE EXPERIMENT.

The cheese was stored in October, 1903, and remained in storage until April 18, 1904, when one-half of the quantity stored at each temperature was placed upon the market, with the exception of that stored at a freezing temperature. The remainder (with the exception of a few cheeses removed for samples) was held until June 20, and then sold. The frozen cheese held at 5° F. was also disposed of in June.

DETAILS OF THE STORAGE.

As already stated, arrangements were made with a refrigerating company of New York City to provide storage and take care of these different lots of cheese. Rooms were arranged in which the temperature could be controlled and kept at 40°, 34°, and 28° F. Automatic tabulators were provided in each room to show continuously the state of the temperature. Close watch was kept of the refrigerating rooms, and the temperatures were noted at least three times daily to see that the thermometers were running properly and that the temperatures were normal. (See fig. 1.)

The different lots of cheese were distributed in the different rooms as indicated in the following table:

TABLE III.—*Distribution of cheese at different temperatures.*

Style of cheese.	Cheese at 40° F.		Cheese at 34° F.		Cheese at 28° F.		Cheese at 5° F.	
	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.
		Lbs. oz.		*Lbs. oz.*		*Lbs. oz.*		*Lbs. oz.*
Cheddar, natural	8	546 2	8	545 4	8	550 4	2	135 13
Cheddar, paraffined	8	547 13	8	540 6	8	538 9	1	67 14
Flat, natural	8	299 14	8	304 10	8	299 6	2	74 7
Flat, paraffined	8	299 12	8	296 8	8	310 11	1	37 8
Young America, natural	6	61 10	6	61 10	6	61 14	2	20 13
Young America, paraffined	6	62 14	6	62 7	6	68 6	2	20 17

SYSTEM OF REFRIGERATION.

The cheese was stored in small rooms specially built for this experiment. Cold air was taken into these rooms from a main cooling room lined with brine pipes. The temperature was governed by sliding doors, which were opened or closed as became necessary in order to hold the different rooms at the required temperature. In the 40-degree room an automatic electric heater was used to assist in regulating the temperature.

RESULTS OF THE EXPERIMENTS.

In presenting the results of these experiments only the summaries will be given. The main points naturally arrange themselves in two distinct parts. Under Part I will be discussed the loss in weight

sustained at the different temperatures, and Part II will include the effect of the different temperatures on the quality of the cheese stored.

I. Loss in Weight at the Different Temperatures.

So few data are available on this subject that the question of shrinkage was made the chief feature of this experiment. The temperatures employed were somewhat lower than those used in ordinary practice. It is therefore of interest to ascertain whether these temperatures possess any advantage over those usually employed. Heavy losses are a great tax to the producer; therefore any factor which can be used to decrease the loss adds so much to the receipts from the milk produced.

DETAILS OF WEIGHING THE CHEESE.

The cheese was all carefully weighed before being placed in storage, records being taken to the nearest ounce. In order that the results might be practical, it was arranged to note at stated periods the losses that occurred. The cheese was therefore weighed every two months from the time it was put in storage, or four times during the period of eight months. The accompanying charts (figs. 2, 3, and 4), showing these data, indicate the loss at any one of these periods.

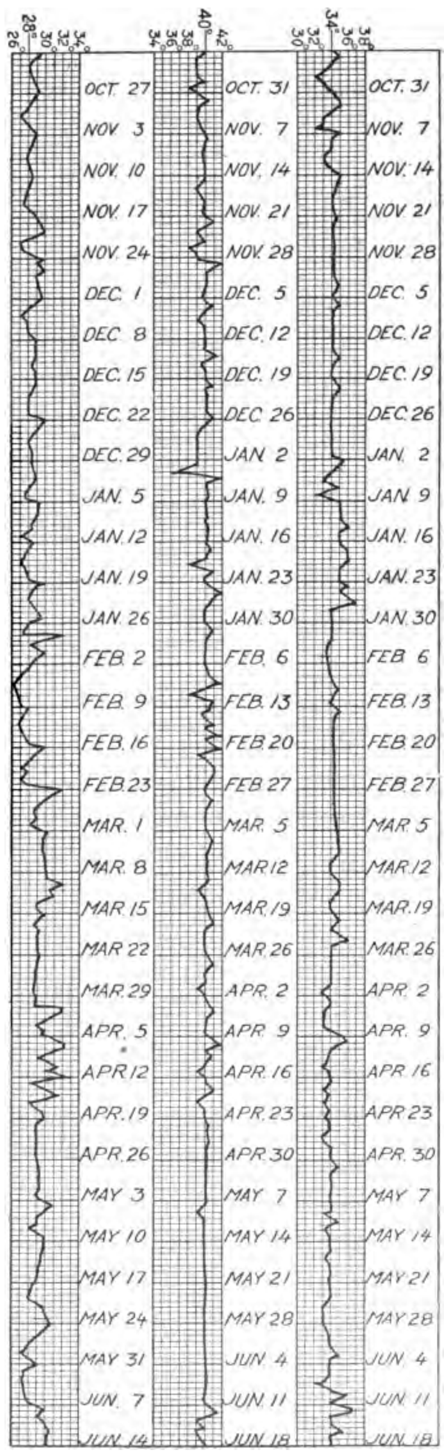


Fig. 1.—Record of temperature variations during entire storage period.

FACTORS INFLUENCING LOSS IN WEIGHT.

There are several factors which affect the rate of shrinkage of cheese in storage, among which may be mentioned temperature, size, and form of cheese, protection of the external surface by paraffin, moisture content of the cheese, and humidity of the air. In this experiment, however, only the first three were studied, and the results will be discussed in relation to each other in the order given.

A. TEMPERATURE.

It has already been shown in Table I that three common types of cheese were selected for studying the rate of loss in storage at temperatures of 40°, 34°, and 28° F. The styles and weights used were: Fifty-one Cheddars, weighing 3,472 pounds 1 ounce; 51 Flats, weighing 1,922 pounds 12 ounces; and 40 Young Americas, weighing 415 pounds 11 ounces, making a total of 5,810 pounds 8 ounces.

The following table shows the losses for each 100 pounds of cheese of the different types at each inspection:

TABLE IV.—*Pounds loss per 100 pounds of cheese.*

NATURAL.

Style of cheese and temperature.	Date stored.	Date of inspection.			
		Dec. 14, 1903 (63 days).	Feb. 15, 1904 (126 days).	Apr. 14, 1904 (185 days).	June 15, 1904 (247 days).
Cheddar:					
40° F	Oct. 12, 1903	2.27	3.68	4.68	5.87
34° F	do	1.62	2.88	4.18	5.12
28° F	do	.93	1.48	1.81	2.88
Flat:					
40° F	do	1.62	2.75	3.90	5.53
34° F	do	1.15	2.30	3.21	4.37
28° F	do	.83	1.32	1.71	2.19
Young America:		(49 days.)	(112 days.)	(171 days.)	(233 days.)
40° F	Oct. 26, 1903	2.37	4.73	6.81	9.34
34° F	do	1.21	3.03	5.02	6.95
28° F	do	.61	1.82	2.83	4.25

PARAFFINED.

Style of cheese and temperature.	Date stored.	Date of inspection.			
		Dec. 14, 1903 (63 days).	Feb. 15, 1904 (126 days).	Apr. 14, 1904 (185 days).	June 15, 1904 (247 days).
Cheddar:					
40° F	Oct. 12, 1903	0.91	1.64	2.02	3.19
34° F	do	.27	.72	1.34	1.36
28° F	do	.19	.37	.61	1.27
Flat:					
40° F	do	.49	1.14	1.46	2.17
34° F	do	.49	.97	1.33	1.63
28° F	do	....	.32	.68	1.02
Young America:		(49 days.)	(112 days.)	(171 days.)	(233 days.)
40° F	Oct. 26, 1903	....	.60	2.00	2.38
34° F	do	.59	1.18	1.58	2.11
28° F	do	....	.60	1.17	1.45

It will be observed that the losses sustained by the different types are greater at 40° F. than at either of the other temperatures. During the period of 247 days the losses for the Cheddars and Flats at

40° F. were 5.87 and 5.53 per cent, respectively, while for the Young Americas for the slightly shorter period of 233 days the loss was 9.34 per cent. At 34° F. the losses were 5.12, 4.37, and 6.95 per cent, respectively, for the same periods, and at 28° F., 2.88, 2.19, and 4.25 per cent. In case of all three types, therefore, the use of the 28° F. temperature for storing prevented over one-half of the loss in weight, as compared with 40° F. The saving, therefore, for a factory making 500 pounds of cheese daily would amount to at least 15 pounds of cheese, or $1.50 per day for the season when Cheddars and Flats are made, and in case of the Young Americas the saving would be even greater, provided the cheese were placed in storage about two weeks from the hoop, as was the case in this experiment.

The losses at periods of 185, 126, and 63 days are also shown, and will assist the dealer in determining at what stage of storage he can most profitably dispose of his product.

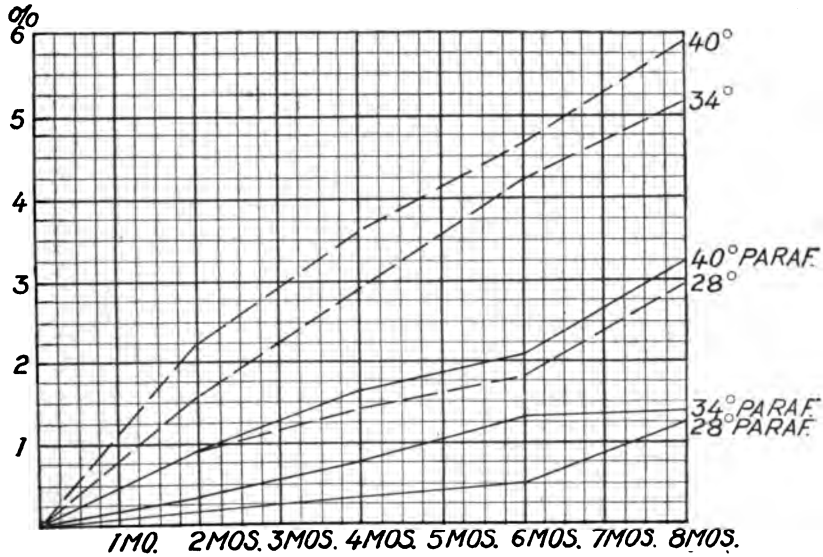


FIG. 2.—Group I, Cheddars. Loss in weight for 8 months. (Broken lines represent natural cheese, solid lines paraffined cheese.)

The difference in the amount of shrinkage was more marked between the temperatures of 28° and 34° F. than between the temperatures of 34° and 40° F.

In order to permit a more ready comparison of the above data, the same are presented in graphic form in figs. 2, 3, and 4.

B. SIZE AND FORM.

The average weight of the Cheddar type of cheese in this experiment was 68 pounds, of the Flats 37 pounds, and of the Young Americas 10.4 pounds. By comparing figs. 2, 3, and 4, it is evident that at 40° F. there was not a great difference in the loss between the Cheddars

and the Flats, which amounted to 5.87 and 5.53 per cent, respectively, for the eight months, while the Young Americas lost 9.34 per cent. The charts of the other temperatures show a similar variation. As pointed out by Babcock and Russell[a] the loss in weight during the curing of cheese is not due entirely to evaporation:

> A cheese in curing is constantly breathing out carbon dioxide, the same as any living organism, due to the development of micro-organisms (bacterial growth within the cheese, as well as molds on the surface).

It is believed that the difference in the losses between the different types of cheese, as shown in the illustrations, is due largely to the difference in size, the weight of the Young Americas being less than one-sixth of that of the Cheddars.

C. PARAFFINING.

A suitable apparatus for paraffining may be described as follows: The framework for use in hoisting and lowering the cheese into the tank consists of four posts extending from floor to ceiling, two of them at one end 6 inches apart, with a similar pair 8 feet away. Between these pairs of posts is a tank 7 feet long, 2 feet wide, and 2 feet deep. A space about 4 inches wide and running lengthwise of the interior of the tank is partitioned off. In this is placed the unmelted paraffin as fast as a supply is needed. This entire tank is inclosed by a pocket tank, there being about one-fourth of an inch space between the tanks at the sides and ends, and one-half to three-fourths of an inch at the bottom. To either side of this pocket is attached about halfway up a 2½-inch water pipe, connected with a tank heated by a stove. It is so arranged that the hot water flows all around and under the tank, thereby heating the paraffin to the boiling point. The best temperature is obtained when the water is kept boiling. Inside and at each end of the main structure is attached a frame over the center of the vat, on which the cheeses are placed edgewise before being lowered into the tank. They are let down by hand with a small rope run over a pulley, a counterbalance with transferable weights being used. It can be balanced to carry two, four, or six cheeses.

The time required for proper paraffining varies according to the condition of the cheese. The cheeses are lowered slowly until covered. They are then allowed to remain fifteen seconds, when they are raised out of the paraffin and allowed to drip until the paraffin on the surface is hard. This usually requires about fifteen seconds.

By this plan of paraffining no odor is given off and the paraffin is left transparent and without smell or taste. An apparatus sometimes used for this purpose heats the paraffin by means of steam pipes placed

[a] Bulletin 49, Bureau of Animal Industry, U. S. Department of Agriculture.

in the bottom of the tank, but this plan frequently "burns" the paraffin, causing it to take on a very offensive odor and flavor. This bad flavor is transmitted to the cheese and detracts from its value. A 35-pound cheese should carry from half an ounce to 2 ounces of paraffin and a 70-pound cheese 3 to 4 ounces. The apparatus outlined above has proved practical and turns out a very attractive product.

One-half of the cheeses in each group were paraffined (see Table IV) by the above method, the object being to determine how far this treatment retards the rate at which cheese loses its moisture. Table IV gives the data as to the percentage of loss in both the paraffined and unparaffined (control) lots. The results are also presented in figs. 2, 3, and 4.

The application of paraffin to cheese of the Cheddar type stored at 40° F. resulted in reducing the loss to little more than one-half that of the unparaffined cheese; at 34° F. nearly three-fourths of the loss was

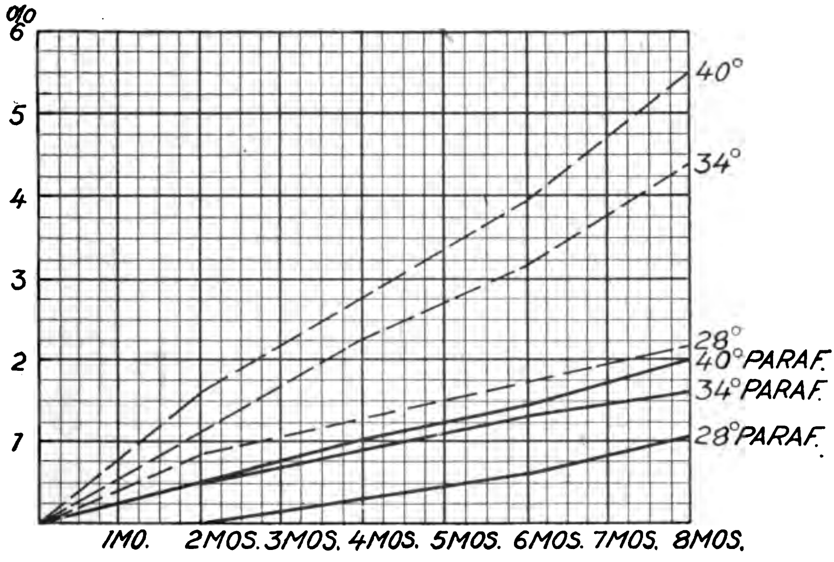


FIG. 3.—Group II, Flats. Loss in weight for 8 months.

prevented, while the losses in the paraffined cheese at 28° F. were reduced almost to a minimum. This was also the case with the unparaffined cheese at this latter temperature, although the losses were still more than twice as great where the cheese was not treated with paraffin.

The relation between the losses in the paraffined and unparaffined cheese in the Flats is similar to that observed in the Cheddars. The curves show that at 40° F. more than one-half of the loss was prevented by coating with paraffin during eight months' storage, while at 34° F. nearly two-thirds of the loss was prevented, and at 28° F. over one-half. Both the paraffined and unparaffined lots in this group lost even less at the latter temperature than did the preceding group.

As would naturally be expected, the Young America type, being the smallest, showed the greatest loss, and fig. 4 demonstrates very clearly the advisability of coating cheese with paraffin, particularly if the cheese handled is of this type. It will be seen from the diagram that there was a very rapid and constant loss in the case of the unparaffined cheese from the date it was placed in storage. This amounted to 9.34 per cent during the eight months' period at the 40°

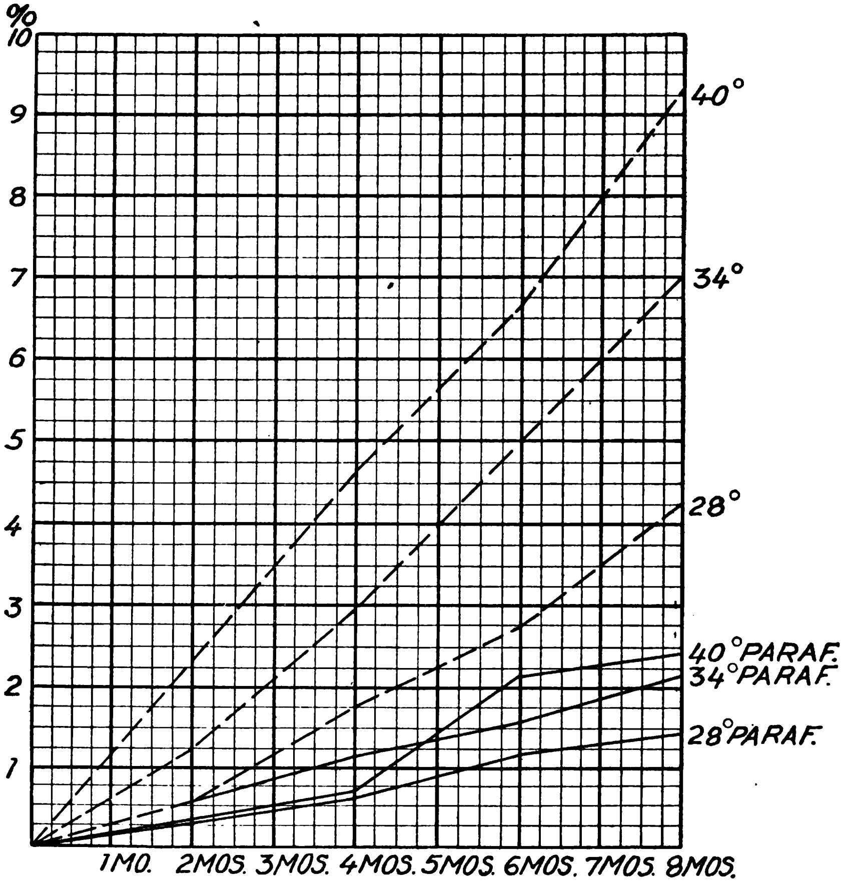


FIG. 4.—Group III, Young Americas. Loss in weight for 8 months.

F. temperature. By coating with paraffin the loss at this temperature was reduced to 2.38 per cent, or nearly three-fourths. At 34° F. two-thirds of the loss was prevented, and at 28° F. practically the same result was noted.

No further argument is needed to demonstrate the value of paraffin as a factor in preventing shrinkage in stored cheese. This, together with the use of low temperatures, results in a great saving to the dealer, and enables him to pay the factory better prices, and the factory in turn to pay more to the producer.

SECTIONS OF CHEDDAR CHEESE AFTER EIGHT MONTHS' STORAGE AT 28° F. (NOT PARAFFINED).

[Lower figure shows small section of above cheese at natural size.]

SECTIONS OF CHEDDAR CHEESE AFTER EIGHT MONTHS' STORAGE AT 28° F. (PARAFFINED).

[Lower figure shows small section of above cheese at natural size.]

II. Effect of Temperature on Quality of Cheese in Storage.

In order to determine the effect of different temperatures on the quality of cheese and to ascertain the length of time required to develop the product to its best selling condition, cheese was inspected and scored by commercial experts once in two months during the period of storage. The averages of the scores of the three judges at the different examinations are presented in Table V (p. 20).

DESCRIPTION OF CHEESE AT TIME OF STORING.

Group I, Cheddar type, was represented by 51 cheeses, weighing a total of 3,472 pounds and 1 ounce, manufactured by the Fish Creek factory, St. Lawrence County, N. Y.; shipped from there on October 5, 1903, and received at New York City on October 9 in the regular course of business. Twenty-five of them were paraffined on October 10.

Description of cheese: Flavor, as nearly perfection as possible; make, fine, close, and firm, showing a few curd fissures; texture, waxy and mellow; color, a strong shade of colored cheese, very uniform; style and finish, fine; surfaces, smooth and firm; the natural cheese had a slight tendency to mold, owing to damp weather; boxing, good; paraffining, very well done; weights, average about 68 pounds. For numerical score, see Table V.

Group II, Flats, was represented by 51 cheeses, weighing 1,922 pounds 12 ounces, manufactured at the Springbrook factory, Cattaraugus County, N. Y.; shipped from there October 3, 1903, and received in New York City October 5 in the regular course of business. Twenty-five of them were paraffined on October 8.

Description of cheese: Flavor, fine to perfect; make, fine, close, firm (one loosely packed in hoop); texture, firm, mellow; color, high to very high, a few inclined to mottle; style and finish, fine; surface, bright, smooth, and firm; boxing, good; paraffining, very well done; weights, average about 38 pounds. For numerical score, see Table V.

Group III, Young Americas, was represented by 40 cheeses, weighing 415 pounds 11 ounces, manufactured at Valley House factory, Sheboygan County, Wis.; shipped from there on October 19, 1903, and received at New York October 23 in the regular course of business. One-half of this lot was paraffined October 24.

Description of cheese: Flavor, fine to perfect; make, fine, close, fairly firm; texture, firm, mellow, waxy; color, good; style and finish, fine; surfaces, bright, smooth, firm; boxing, good; paraffining, well done; weights, average about 10½ pounds. For numerical score, see Table V.

RESULT OF FIRST SCORING.

The first scoring took place December 14, 1903, 63 days after placing in storage for the Cheddars and Flats, and 49 days for the Young Americas.

Group I, Cheddars.—At the 40° F. temperature all the cheese was found to be in fine condition, quite equal to that when stored, while at 34° and 28° F. there was some mold on the tops and sides of the cheeses not paraffined. The 28° F. product was highest in both flavor and texture and perfect in color and finish, scoring a total of 99.5. The 34° F. cheese scored 99.1, and the 40° F. cheese 99.

Group II, Flats.—These were slightly moldy at the 28° and 34° F. temperatures, while at 40° F. they presented a good appearance. The judges reported that this group seemed to be developing a winterish flavor, undoubtedly resulting from the low temperature, although this was not noticeable in either the Cheddars or the Young Americas. This style also scored its highest on all points at the 28° F. temperature, the total being 97. At 34° F. the cheese was marked down 3 points for color. The total score at 40° F. was 95.2.

Group III, Young Americas.—These showed some mold at all three temperatures. It is rather remarkable that they scored the same at all temperatures on all four points, including texture, flavor, color, and finish, the total being 99.7.

Group IV, stored at 5° F.—These cheeses were frozen solid, showing ice on the surfaces, and it was impossible to bore them with heavy triers. Near the end of the experiment, however, they were thawed out and scored, the result of this scoring being given elsewhere. At the first inspection the surfaces and sides of the cheese were wrinkled and cracked, owing to the action of the cold.

RESULT OF SECOND SCORING.

The second commercial scoring took place February 15, 1904, at the end of 126 days for the Cheddars and Flats and 112 days for the Young Americas.

Group I, Cheddars.—The cheese in the 40° F. room was found to be in almost perfect condition, which was rather a surprise, particularly in case of that not paraffined. The cheese was bright and had no particular appearance of being cold stored. The average of the scores of the judges gave the 40° F. product 99.3, which is 0.3 higher than the scoring of the 28° F. cheese and 1.5 higher than that of the cheese stored at 34° F. It will be remembered that at the first scoring the 28° F. Cheddars scored the highest; the difference in the scores, however, is not great. At 28° and 34° F. the cheese was more or less moldy, and at the latter temperature 1.2 points were taken off for flavor.

Group II, Flats.—This class of cheese showed some deterioration in flavor and color in all the rooms, which indicated that there was some chemical or latent defect in them which could not be accounted for without chemical analysis. The highest score, 95.2, was given to the 40° F. cheese, as in the case of the Cheddars, while the 28° F. cheese received 94, and the 34° F. product 93.1.

Group III, Young Americas.—This was the only kind which showed any mold at 40° F. at this trial. Aside from the mold, however, the cheese was almost perfect, and scored 99. At 34° and 28° F. the cheeses were quite moldy and a little off in flavor, scoring 97.5 and 96.8, respectively.

RESULT OF THIRD SCORING.

The third commercial scoring took place April 14, 1904, at the end of 185 days for the Cheddars and Flats and 171 days for the Young Americas. All of the cheeses at this scoring, with the exception of those coated with paraffin, were covered more or less with mold.

Group I, Cheddars.—As was the case at the second jury trial, the 40° F. cheese scored highest—99.3—the only deduction from perfect score being on point of texture. At the temperatures of 34° and 28° F. the cheese was quite heavily covered with mold. The judges gave them scores of 97.1 and 97, respectively.

Group II, Flats.—As in the last test, this style of cheese was found to be considerably off in flavor and color at all of the temperatures. That stored at 34° F. was given the highest score—93.4—while the 40° and 28° F. cheese was scored 92.8 and 88.8, respectively.

Group III, Young Americas.—The 34° F. cheese of this type scored highest—98.2—as was the case with the Flats, while the 40° F. product followed closely with 98.1 points, and the 28° F. product scored 96, the latter being marked down for flavor and texture as well as finish.

RESULT OF FOURTH SCORING.

The fourth commercial scoring took place June 15, 1904, 247 days after the cheese was placed in storage in the case of the Cheddars and Flats and 233 days in the case of the Young Americas.

Group I, Cheddars.—The cheese scored remarkably high considering the length of time it had been in storage. The judges gave the cheese at 40° F., 49.5 for texture, 25 for flavor, 15 for color, and 9.3 for finish, making a total of 98.8. This is 1.3 points higher than it scored when first placed in storage. At 34° F. the total score was 98.2 and at 28° F. 96.2.

Group II, Flats.—For some reason this class of cheese scored highest at 34° F., the judges giving it a total of 95.2. The cheese at 40° F. was next with a score of 92.3, and the 28° F. cheese last with a score of 88.3. It will be noted that this style of cheese scored less at the fourth scoring than when it was placed in storage, and, as previously stated, this was probably due to some defect in the making.

Group III, Young Americas.—These held their quality remarkably well, scoring for 40°, 34°, and 28° F., 97.9, 97.5, and 96.3, respectively, against 98.8, 98, and 98.1 at the time the cheese was placed in storage. The greatest deterioration was in the appearance or finish of the cheese and in the flavor; but as the lowest score for all temperatures was 97.5 points, it is rated as high quality even after eight months' storage.

The following tabulation is deduced from the detailed numerical scores made by the three judges, showing the average scores as to texture, flavor, color, and finish (surfaces):

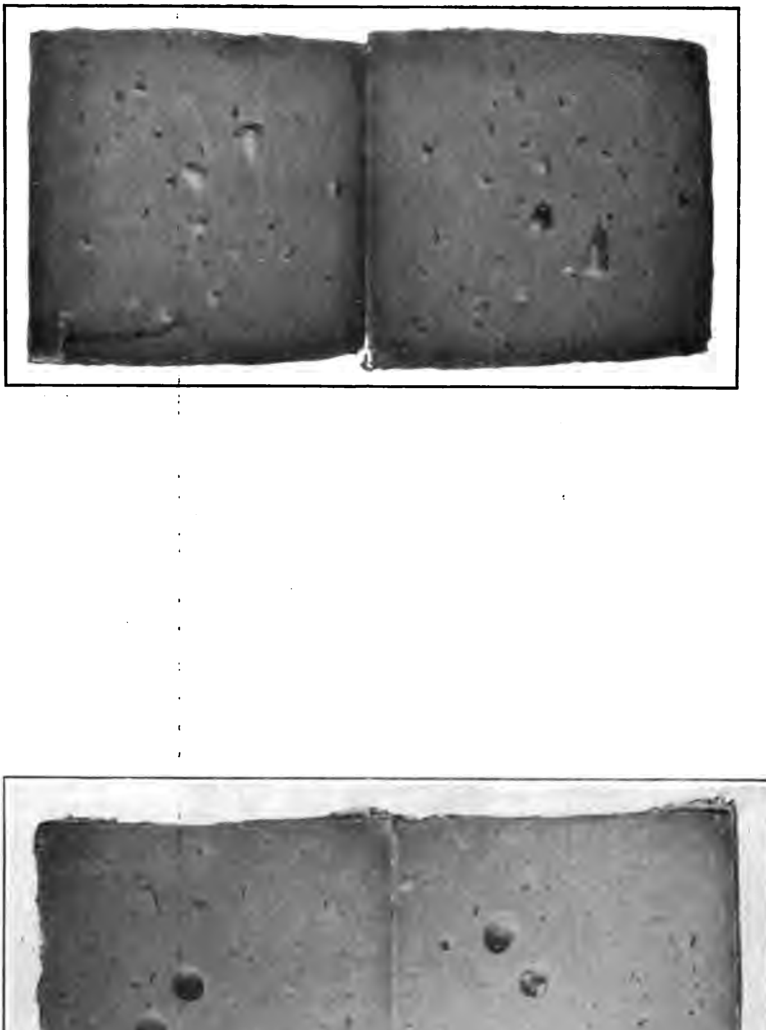
TABLE V.—*Summary of the scoring.*

AT 40° F.

Style and condition of cheese.	Date of score.	Texture.	Flavor.	Color.	Finish.	Total score.
Cheddar:						
Natural	Oct. 12, 1903	48.5	24.0	15.0	10.0	97.5
	Dec. 14, 1903	49.7	24.3	15.0	10.0	99.0
	Feb. 15, 1904	49.3	25.0	15.0	10.0	99.3
	Apr. 14, 1904	49.3	25.0	15.0	10.0	99.3
	June 15, 1904	49.5	25.0	15.0	9.3	98.8
Paraffined	Oct. 12, 1903	49.7	25.0	15.0	10.0	99.7
	Dec. 14, 1903	49.8	24.8	15.0	10.0	99.6
	Feb. 15, 1904	49.3	24.3	15.0	10.0	98.6
	Apr. 14, 1904	49.3	24.7	15.0	10.0	99.0
	June 15, 1904	49.3	25.0	15.0	10.0	99.3
Flat:						
Natural	Oct. 12, 1903	48.1	24.7	13.4	10.0	96.2
	Dec. 14, 1903	48.8	23.0	13.4	10.0	95.2
	Feb. 15, 1904	49.4	23.3	12.5	10.0	95.2
	Apr. 14, 1904	48.9	23.2	10.7	10.0	92.8
	June 15, 1904	48.3	23.3	11.5	9.2	92.3
Paraffined	Oct. 12, 1903	48.7	24.6	13.7	10.0	97.0
	Dec. 14, 1903	49.5	23.7	13.0	10.0	96.2
	Feb. 15, 1904	49.1	21.7	13.0	10.0	93.8
	Apr. 14, 1904	48.8	21.4	12.1	9.9	92.2
	June 15, 1904	48.5	23.1	11.5	9.2	92.3
Young America:						
Natural	Oct. 26, 1903	49.0	25.0	14.8	10.0	98.8
	Dec. 14, 1903	50.0	24.7	15.0	10.0	99.7
	Feb. 15, 1904	49.3	25.0	15.0	9.7	99.0
	Apr. 14, 1904	49.3	25.0	15.0	8.8	98.1
	June 15, 1904	49.3	24.7	15.0	8.9	97.9
Paraffined	Oct. 26, 1903	48.8	24.2	15.0	10.0	98.0
	Dec. 14, 1903	50.0	24.5	15.0	10.0	99.5
	Feb. 15, 1904	49.3	25.0	15.0	10.0	99.3
	Apr. 14, 1904	49.3	23.8	15.0	10.0	98.1
	June 15, 1904	49.3	24.3	15.0	9.7	98.3

AT 34° F.

Style and condition of cheese.	Date of score.	Texture.	Flavor.	Color.	Finish.	Total score.
Cheddar:						
Natural	Oct. 12, 1903	49.7	24.8	15.0	10.0	99.5
	Dec. 14, 1903	49.8	24.4	15.0	9.9	99.1
	Feb. 15, 1904	48.8	24.3	15.0	9.7	97.8
	Apr. 14, 1904	49.2	24.3	15.0	8.6	97.1
	June 15, 1904	49.3	24.9	15.0	9.0	98.2
Paraffined	Oct. 12, 1903	49.5	24.5	15.0	10.0	99.0
	Dec. 14, 1903	50.0	24.7	15.0	10.0	99.7
	Feb. 15, 1904	49.0	24.3	15.0	10.0	98.3
	Apr. 14, 1904	49.3	24.5	15.0	9.9	98.7
	June 15, 1904	49.1	24.9	15.0	10.0	99.0
Flat:						
Natural	Oct. 12, 1903	48.9	24.8	13.8	10.0	97.5
	Dec. 14, 1903	49.3	23.5	12.0	9.9	94.7
	Feb. 15, 1904	48.6	22.8	12.0	9.7	93.1
	Apr. 14, 1904	48.7	23.3	12.0	9.4	93.4
	June 15, 1904	48.9	23.5	14.0	8.8	95.2
Paraffined	Oct. 12, 1903	48.5	25.0	14.0	10.0	97.5
	Dec. 14, 1903	49.2	23.2	12.1	9.8	94.3
	Feb. 15, 1904	48.7	22.2	12.0	9.8	92.7
	Apr. 14, 1904	48.7	22.7	10.0	9.7	91.1
	June 15, 1904	48.9	23.0	10.5	9.3	91.7
Young America:						
Natural	Oct. 26, 1903	48.7	24.3	15.0	10.0	98.0
	Dec. 14, 1903	50.0	24.7	15.0	10.0	99.7
	Feb. 15, 1904	49.3	23.5	15.0	9.7	97.5
	Apr. 14, 1904	49.3	24.9	15.0	9.0	98.2
	June 15, 1904	49.2	24.5	15.0	8.8	97.5
Paraffined	Oct. 26, 1903	48.7	24.1	15.0	10.0	97.8
	Dec. 14, 1903	50.0	24.7	15.0	10.0	99.7
	Feb. 15, 1904	49.3	24.2	15.0	10.0	98.5
	Apr. 14, 1904	49.3	24.3	15.0	10.0	98.6
	June 15, 1904	49.3	24.5	15.0	9.7	98.5



SECTIONS OF "YOUNG AMERICA" CHEESE AFTER EIGHT MONTHS' STORAGE AT 40° F.

[Cheese on left not paraffined; cheese on right paraffined.]

TABLE V.—*Summary of the scoring*—Continued.

AT 28° F.

Style and condition of cheese.	Date of score.	Texture.	Flavor.	Color.	Finish.	Total score.
Cheddar:						
Natural	Oct. 12, 1903	49.5	24.1	15.0	10.0	98.6
	Dec. 14, 1903	50.0	24.5	15.0	10.0	99.5
	Feb. 15, 1904	49.3	25.0	15.0	9.7	99.0
	Apr. 14, 1904	49.2	24.7	15.0	8.1	97.0
	June 15, 1904	49.0	24.2	15.0	8.0	96.2
Paraffined	Oct. 12, 1903	49.2	24.1	15.0	10.0	98.3
	Dec. 14, 1903	50.0	24.1	15.0	10.0	99.1
	Feb. 15, 1904	49.7	25.0	15.0	10.0	99.7
	Apr. 14, 1904	49.2	24.3	15.0	9.5	98.0
	June 15, 1904	49.0	24.2	15.0	9.8	98.0
Flat:						
Natural	Oct. 12, 1903	48.7	24.6	14.9	10.0	98.2
	Dec. 14, 1903	49.7	23.6	13.7	10.0	97.0
	Feb. 15, 1904	48.8	23.4	12.0	9.8	94.0
	Apr. 14, 1904	48.4	22.7	10.0	7.7	88.8
	June 15, 1904	48.2	23.0	10.0	7.1	88.3
Paraffined	Oct. 12, 1903	48.4	24.5	13.8	10.0	96.7
	Dec. 14, 1903	49.9	23.8	12.0	10.0	95.7
	Feb. 15, 1904	48.6	23.2	12.0	10.0	93.8
	Apr. 14, 1904	48.5	23.2	13.5	9.7	94.9
	June 15, 1904	48.3	22.5	10.0	8.9	89.7
Young America:						
Natural	Oct. 26, 1903	48.8	24.3	15.0	10.0	98.1
	Dec. 14, 1903	50.0	24.7	15.0	10.0	99.7
	Feb. 15, 1904	49.3	22.8	15.0	9.7	96.8
	Apr. 14, 1904	49.2	23.5	15.0	8.3	96.0
	June 15, 1904	49.3	24.1	15.0	7.9	96.3
Paraffined	Oct. 26, 1903	48.9	24.6	15.0	10.0	98.5
	Dec. 14, 1903	50.0	24.7	15.0	10.0	99.7
	Feb. 15, 1904	49.3	23.5	15.0	10.0	97.8
	Apr. 14, 1904	49.1	23.6	15.0	10.0	97.7
	June 15, 1904	49.3	24.3	15.0	9.4	98.0

INFLUENCE OF PARAFFIN ON THE QUALITY OF CHEESE IN STORAGE.

The use of paraffin on cheese to prevent the growth of mold, particularly when the cheese is stored at low temperatures, is now a common practice. It is generally agreed that the paraffin should not be applied until the cheese is ten days or two weeks old, as it is better to give time for the surface to dry. It has been an open question, however, whether the quality of the cheese so treated was improved or deteriorated. The prejudice which has existed among some retailers against the use of paraffin is gradually disappearing, and it may be said that many of the objections against the practice are quite groundless. The greatest objection has come from dealers who claim a considerable loss in weight in removing the cloths from the cheese. The commissioner of agriculture and dairying of Canada, after conducting some experiments along this line, sums up the matter as follows:

> There is, of course, an extra loss of weight in stripping a paraffined cheese equal to the quantity of wax adhering to it. This need not be more than 4 or 5 ounces. If the grocer has a paraffined cheese in his possession a week before it is cut he will gain more in the saving of shrinkage than is lost in the stripping of the cheese, or in the shrinkage afterwards. When these things are better understood and the advantages of paraffining are fully realized, the objections now raised should be more than offset.

In our storage experiments the influence of paraffin upon the quality of cheese as shown by the scores for flavor and texture was studied.

As already stated, for this purpose one-half of the cheeses in each group were coated with paraffin, the same cheese being used in experiments on shrinkage. A summary of the scores of the paraffined and normal cheese is entered in Table V for comparison.

A study of the figures indicates that in the opinion of the judges there was but little difference in the quality of the natural and paraffined product. Sometimes the one scored highest and sometimes the other. Naturally the paraffin prevented to a large extent the growth of mold, thus maintaining the cheese in a clean and bright condition. The higher score for finish obtained by the paraffined cheese has a tendency to increase the total, and for this reason the paraffined product scored highest in the final average. This is brought out more clearly in the following tabulation:

TABLE VI.—*Comparison of scores of natural and paraffined cheese.*

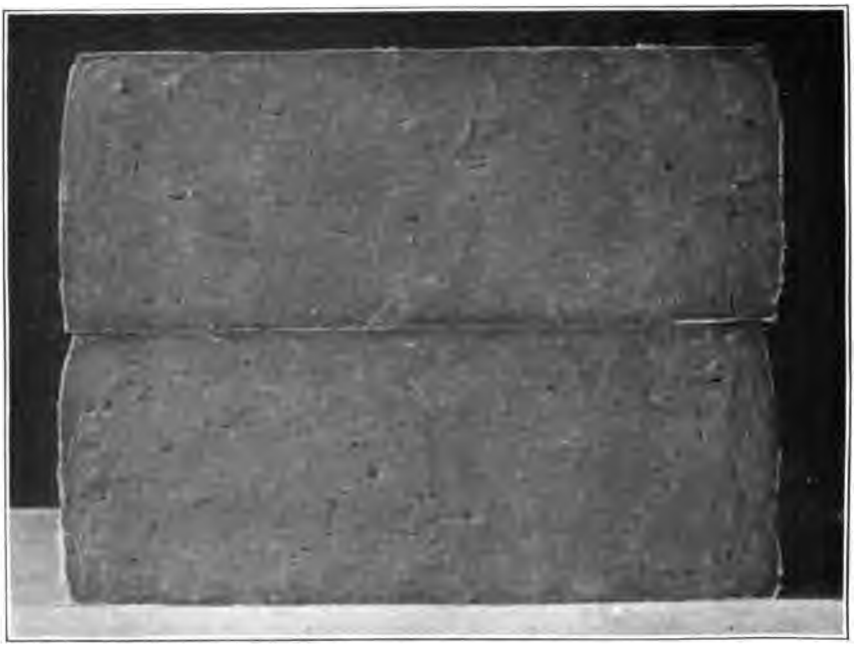
Style of cheese.	Storage temperature.	Natural.					Paraffined.				
		Oct. 12.	Dec. 14.	Feb. 15.	Apr. 14.	June 15.	Oct. 12.	Dec. 14.	Feb. 15.	Apr. 14.	June 15.
	°F.										
Cheddar	40	97.5	99.0	99.3	99.3	98.8	99.7	99.6	98.6	99.0	99.3
	34	99.5	99.1	97.8	97.1	98.2	99.0	99.7	98.3	98.7	99.0
	28	98.6	99.5	99.0	97.0	96.2	98.3	99.1	99.7	98.0	98.0
	5	......	......	......	80.0	......	......	......	......	......	......
Flat	40	96.2	95.2	95.2	92.8	92.3	97.0	96.2	93.8	92.2	92.3
	34	97.5	94.7	93.1	93.4	95.2	97.5	94.3	92.7	91.1	91.7
	28	98.2	97.0	94.0	88.8	88.3	96.7	95.7	93.8	94.9	89.7
	5	......	......	......	......	......	......	......	......	80.0	......
		Oct.26					Oct.26				
Young America	40	98.8	99.7	99.0	98.1	97.9	98.0	99.5	99.3	98.1	98.3
	34	98.0	99.7	97.5	98.2	97.5	97.8	99.7	98.5	98.6	98.5
	28	98.1	99.7	96.8	96.0	96.3	98.5	99.7	97.8	97.7	98.0
	5	......	......	......	......	......	......	......	......	85.0	......

EFFECT OF FREEZING ON THE QUALITY.

In addition to the experiments at the higher temperatures, it was thought desirable to store a small quantity at a freezing temperature, in order to determine the general effects of freezing on the quality. For this purpose 3 Cheddars weighing 203 pounds 11 ounces, 3 Flats weighing 111 pounds 15 ounces, and 4 Young Americas weighing 41 pounds 14 ounces, were placed in storage at 5° F. One each of the Cheddars and Flats and two of the Young Americas were paraffined. The Cheddars and Flats were placed in storage October 12 and the Young Americas October 26. As was expected, the cheese immediately froze hard, ice showing on the surfaces, and after a time the tops and sides appeared to be lumpy, indicating that the cheese was being disintegrated by the cold. The judges found it impossible to bore these cheeses at the time the others were inspected, and they were therefore allowed to remain until April 18, six months after being placed in storage, when they were taken out and kept at a temperature of about 70° F. until thoroughly thawed out. The frozen cheese cut well and presented at first a very natural appearance. The surfaces, however, dried faster than is usual with cut cheese, and in case

SECTIONS OF CHEDDAR CHEESE AFTER FIVE AND ONE-HALF MONTHS' STORAGE AT 5° F. (FROZEN).

[Lower figure shows small section of above cheese at natural size.]



SECTIONS OF "FLATS" AFTER FIVE AND ONE-HALF MONTHS' STORAGE AT 5° F. (FROZEN).

[Lower figure shows small section of above cheese at natural size.]

of the Cheddar type there was a marked tendency to crumble. As would naturally be expected, the low temperature prevented the cheese from ripening, and the flavor was by no means attractive. The frozen flavor and the disintegration of the curd are serious and fatal defects, so far as handling the cheese commercially is concerned, as such cheese can be sold only at a greatly reduced price.

When this cheese was scored a number of dealers in the trade were invited to come and inspect it, but there was little interest manifested. Of the three types the Young Americas showed much better than the others, both as to texture and flavor, but even these had an insipid taste and were in a crumbly condition. Another effect noted in the frozen cheese was its mottled appearance. This was not shown in the cheese stored at any of the other temperatures.

The following tabulation shows the score of frozen cheese after six months' storage, as reported by the judges:

TABLE VII.—*Score of cheese stored at 5° F.*

Style of cheese.	Texture.	Flavor.	Color.	Finish.	Total.
Cheddar	40	20	10	10	80
Flat	40	20	10	10	80
Young America	40	20	15	10	85

GENERAL SUMMARY.

This work was designed as distinctly a storage experiment, having little regard for the question of curing. The principal object was to answer the question, How do different temperatures affect the weight and quality of cheese stored for considerable periods? The fact was also kept in mind while these experiments were in progress that the chief purpose in storing cheese commercially is to make a profit. It is believed that some valuable information has been collated as to the best temperatures for holding cheese, also in regard to the shrinkage in weight connected with such temperatures. It has also been shown that paraffining cheese is economical for storage purposes, both as to loss in weight and the general appearance of the product.

RESULTS IN REGARD TO WEIGHT.

We have seen that the storage of cheese at a temperature near the freezing point greatly reduces the loss due to shrinkage in weight as compared with that which occurs at higher temperatures, that such loss is still further prevented by covering cheese with paraffin, and that the combination of these two conditions reduces the shrinkage to a minimum.

Less shrinkage as a result of using low temperatures.—On the basis of the longest period of time for which we were able to compare the results at the different temperatures employed (247 days for Cheddars

and Flats and 233 days for Young Americas), it was found that the Cheddar type stored at 40° F. had lost on an average 5.87 pounds for 100 pounds of cheese, the cheese at 34° F. had lost 5.12 pounds, and that at 28° F. 2.88 pounds. For 100 pounds of cheese originally placed in the storage rooms at the different temperatures we had for sale at the end of the storage period 94.13 pounds of cheese stored at 40° F., 94.88 pounds stored at 34° F., and 97.12 pounds stored at 28° F. Assuming that the cheese sold at a uniform price of 10 cents a pound (it having been shown that the scores were not materially different), the receipts from the original 100 pounds of the cheese at the different temperatures would be as follows:

Cheddars stored at 40° F	$9.41
Cheddars stored at 34° F	9.49
Cheddars stored at 28° F	9.71

Under these conditions the receipts from the cheese stored at 28° F. are 22 cents per 100 pounds more than from that stored at 34° F. and 30 cents more than from that stored at 40° F. With the use of paraffin, as shown later, the differences are even greater.

Following the same methods in presenting the results with the Flats, we find that at 40° F. this class of cheese has lost on an average 5.53 pounds for 100 pounds of cheese; at 34° F., 4.37 pounds, and at 28° F., 2.19 pounds. For 100 pounds of cheese originally placed in the storage rooms at the different temperatures we therefore had for sale at the end of the storage period 94.47 pounds of cheese stored at 40° F., 95.63 pounds stored at 34° F., and 97.81 pounds stored at 28° F. Assuming here also that the cheese sold at a uniform price of 10 cents a pound, the receipts from the original 100 pounds of this cheese at the different temperatures would be as follows:

Flats stored at 40° F	$9.45
Flats stored at 34° F	9.56
Flats stored at 28° F	9.78

The receipts, therefore, for the cheese stored at 28° F. would be 22 cents per 100 pounds more than for that stored at 34° F. and 33 cents more than for that stored at 40° F.

Again a similar consideration of the Young Americas shows that at 40° F. this class lost on an average 9.34 pounds for 100 pounds of cheese; at 34° F. the loss was 6.95 pounds, and at 28° F. 4.25 pounds. For 100 pounds originally placed in the storage rooms at the different temperatures we had for sale at the end of the storage period 90.66 pounds of cheese stored at 40° F., 93.55 pounds stored at 34° F., and 95.75 pounds stored at 28° F. Assuming again the same selling price for this cheese as for the others, the receipts for the original 100 pounds at the different temperatures would be as follows:

Young Americas stored at 40° F	$9.06
Young Americas stored at 34° F	9.30
Young Americas stored at 28° F	9.57

On this basis the receipts for the cheese stored at 28° F. would be 27 cents per 100 pounds more than for that stored at 34° F., and 51 cents more than for that stored at 40° F.

Influence of size and type of cheese.—The three types of cheese in this experiment—namely, Cheddars, Flats, and Young Americas—weighed on an average 68, 37.7, and 10.4 pounds, respectively. It would naturally be expected that the three kinds would vary somewhat in the amount of shrinkage. The results on this point show that at the 40° F. temperature there was not a great difference in the loss for Cheddars and Flats, the amount for the entire storage period (eight months) being 5.87 and 5.53 per cent, respectively. The Young Americas, however, which were much smaller, lost 9.34 per cent. A similar variation is shown at the other temperatures.

Influence of paraffin.—At the end of eight months the Cheddar cheese coated with paraffin had lost only 3.19 pounds for each 100 pounds of cheese originally placed in storage at 40° F., 1.36 pounds at 34° F., and 1.27 pounds at 28° F. The saving thus effected, based on the price of cheese at 10 cents a pound, would average about 27 cents for 100 pounds of cheese stored at 40° F., 38 cents per 100 pounds at 34° F., and 16 cents per 100 pounds at 28° F. This small saving at the 28° F. temperature is due to the fact that the loss in weight was very small where no paraffin was used, and while the paraffin reduced this loss still further, the effect is not as marked as in the case of the higher temperatures. Comparing these results where the greatest saving was effected, namely, the combination of the 28° F. temperature with paraffining as against the 40° F. temperature without paraffining, we have a difference of 46 cents per 100 pounds in favor of the former.

The Flats gave a similar result, the saving with paraffined cheese at 28° F., as compared with natural cheese at 40° F., being the same—about 46 cents.

In the case of the Young Americas the saving was more marked, this cheese having lost only 2.38 pounds per 100 pounds at 40° F., 2.11 pounds at 34° F., and 1.45 pounds at 28° F. Comparing the cheese kept at 40° F. not covered with paraffin with that at 28° F. covered with paraffin, there would be a difference of about 52 cents per 100 pounds in favor of the paraffined product at the low temperature.

Results in Regard to Quality.

The cheese was carefully scored by three judges every two months, and the results in detail have been given in preceding tables. It is only necessary here to state their findings in a general way.

Group I, Cheddars.—This group showed excellent keeping quality during the whole eight months. At the first scoring, which took place after two months' storage, the cheese at the three temperatures, namely,

28°, 34°, and 40° F., scored 99.5, 99.1, and 99, respectively. At the second, third, and fourth scorings the cheese at 40° F. rated the highest, and the final average for the four scorings at each of the temperatures of 40°, 34°, and 28° F. are 99.1, 98.05, and 97.9, respectively.

Group II, Flats.—This type of cheese showed some deterioration at all temperatures, even at the first scoring, and gradually continued to fall off in quality until the close of the storage period. That stored at 34° F. gave the highest average for the four scorings, namely, 94.1 against 93.9 for 40° F., and 92.02 for 28° F.

Group III, Young Americas.—The cheese in this group held its quality, almost without exception, throughout the entire experiment. Here, again, as in the case of the Cheddars, the cheese at 40° F. gave the highest average score for the four inspections, namely, 98.7. This was followed closely by the cheese at 34° F. with a score of 98.2, that at 28° F. scoring 97.2.

It appears from the above statements that the different temperatures used had no very marked influence upon the quality of the cheese, and, as stated at the outset, this was one of the minor points of this experiment.

EFFECT OF PARAFFIN ON QUALITY.

One-half of each group of cheeses was paraffined just before being placed in storage; otherwise they were handled the same as unparaffined cheese. The results of the experiment indicate that the paraffining had no prejudicial effect upon any of the types of cheese at any temperature; in fact, in the case of the Cheddars and Young Americas the paraffined product scored a little the highest at all three temperatures in the final average. A similar result was recorded with the Flats at the lowest température, but at 34° and 40° F. the natural cheese in this class was slightly ahead.

O

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY.—BULLETIN No. 84.

A. D. MELVIN, CHIEF OF BUREAU.

INVESTIGATIONS IN THE MANUFACTURE AND STORAGE OF BUTTER.

I.—THE KEEPING QUALITIES OF BUTTER MADE UNDER DIFFERENT CONDITIONS AND STORED AT DIFFERENT TEMPERATURES.

BY

C. E. GRAY,

Dairy Expert in Charge of Butter Investigations, Dairy Division, Bureau of Animal Industry.

WITH REMARKS ON THE SCORING OF THE BUTTER.

BY

G. L. McKAY,

Professor of Dairying, Iowa State College.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1906.

DAIRY DIVISION.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., April 19, 1906.

Sir: I have the honor to transmit herewith, for publication as a bulletin of this Bureau, a report of certain investigations made by the Dairy Division in the manufacture and storage of butter. This represents the beginning of an important line of work, which has been undertaken with the object of giving practical assistance to the butter trade.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

INTRODUCTION.

This bulletin is the first of a series to be issued dealing with investigations in the manufacture and storage of butter, a line of work recently taken up by the Dairy Division. Every step in the making and storage of butter is so intimately connected with every other step that the work of the experts assigned to these studies is never complete at any stage, but the results will be published from time to time as facts enough are gathered to warrant publication. The reports of this work will appear under the general title of "Investigations in the Manufacture and Storage of Butter," with such subtitles as will indicate the particular line or phase of work discussed in each bulletin.

The present number treats of the keeping qualities of butter made under different conditions and stored at different temperatures. The plan of this investigation is to study the keeping qualities of butter—

(1) As affected by temperature of storing.

(2) As affected by pasteurization of cream.

(3) As affected by salting.

(4) As affected by package in which it is stored, as (*a*) tubs, and (*b*) cans so-called hermetically sealed.

(5) As affected by air in the package, as in (*a*) cans full, and (*b*) cans partially full.

This work was outlined by Mr. C. E. Gray, dairy expert in the Dairy Division, and is being carried out under his supervision. This report gives the results of the first season's work (1905–6). The experiments are being continued, and such portions of the work as may seem to be incomplete or inconclusive are already in process of repeating. It is thought advisable to make this preliminary report at this time, however, so that persons storing butter may have during the coming season the results thus far obtained, and any advantages that may be derived from them.

The butter used in these experiments was made by Mr. Gray, some at Topeka, Kans., and some at Monticello, Iowa, and was stored in special rooms built and equipped for the Dairy Division in Chicago, Ill., by Messrs. A. Booth & Co.

The Iowa Agricultural Experiment Station participated in the work by furnishing the services of Prof. G. L. McKay as expert in scoring the butter. He was assisted by Mr. P. H. Kieffer, assistant dairy commissioner of Iowa. Their excellent judgment of the quality of butter has added materially to the completeness and value of the work. Professor McKay's statement concerning the scoring follows Mr. Gray's report of the test.

ED. H. WEBSTER,
Chief of the Dairy Division.

CONTENTS.

INVESTIGATIONS IN THE MANUFACTURE AND STORAGE OF BUTTER.

THE KEEPING QUALITIES OF BUTTER MADE UNDER DIFFERENT CONDITIONS AND STORED AT DIFFERENT TEMPERATURES.

By C. E. Gray.

MAKING THE BUTTER.

As shown in Table I, all butter used in this investigation was prepared from five lots of cream, each lot containing enough butter fat to make about 1,200 pounds of butter, or two churnings. The quality of the cream in lots 1, 2, and 3 was about the same, all being sour. The quality of lots 4 and 5 was good, the cream being perfectly sweet. The cream in lot 5 was the better of the two, having been received at the creamery on the same day it was separated. Each of lots 1, 2, and 3 was mixed thoroughly in a vat, then divided into two parts about equally, one part being marked A and the other B, as shown in the table. There being in the creamery no vats of sufficient capacity to hold either lots 4 or 5, the cans of cream in each lot were divided into two parts, which were also marked A and B, respectively. The parts from each lot marked A were not pasteurized; the parts marked B were pasteurized.

Each churning after washing was salted to contain a low percentage of salt, and worked about the usual number of revolutions. Half of each churning was then removed from the churn and packed. To the parts remaining in the churn more salt was added and the butter was worked just enough to incorporate the salt evenly. This method of procedure gave from each lot of cream one churning of butter from unpasteurized cream and one churning from pasteurized cream, one-half of each churning with a low percentage of salt and the other half with a higher percentage of salt.

The system used in marking gave to each kind of butter three symbols, the first (1, 2, 3, 4, or 5) denoting the lot of cream from which the butter was made, the second (A or B) whether the cream was unpasteurized or pasteurized, and the third (L or H) whether the butter contained a low or high percentage of salt. For example, 1 A L would indicate the butter from the first lot of cream, unpasteurized, and lightly salted; 1 A H, from first lot of cream, unpasteurized, heavily salted; 1 B H, from first lot of cream, pasteurized, heavily salted; 1 B L, from first lot of cream, pasteurized, lightly salted; 2 A L, from second lot of cream, unpasteurized, lightly salted, etc.

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TABLE I.—*Details of butter making and composition of butter.*

	Lot of cream No. 1, taken June 30, 1905; condition sour; quality fair; acidity 0.560 per cent.		Lot of cream No. 2, taken June 30, 1905; condition sour; quality fair; acidity 0.575 per cent.		Lot of cream No. 3, taken June 30, 1905; condition sour; quality fair; acidity 0.558 per cent.		Lot of cream No. 4, taken July 10, 1905; condition sweet; quality good; acidity not taken.		Lot of cream No. 5, taken July 10, 1905; condition sweet; quality very good; acidity not taken.	
	1 A.	1 B.	2 A.	2 B.	3 A.	3 B.	4 A.	4 B.	5 A.	5 B.
Pasteurized		165°–170° F		165°–170° F		165°–170° F		170° F		170° F.
Starter added	10 p. ct	10 p ct.	10 p. ct	10 p. ct	10 p. ct	10 p. ct	10 p. ct	10 p. ct	10 p. ct	10 p. ct.
Fat	29.3 p. ct	29.2 p. ct	29.4 p. ct	29.3 p. ct	31.4 p. ct	31.6 p. ct	32 p. ct	34 p. ct	39 p. ct	37 p. ct.
Time held before churning	6 hrs	3 h. 55 m	6 h. 25 m	6 h. 40 m	21 h. 40 m	20 h. 40 m	2 h. 42 m	6 h. 55 m	18 h. 10 m	22 h. 40 m.
Acidity when churned	0.576 p. ct	0.576 p. ct	0.594 p. ct	0.576 p. ct	0.576 p. ct	0.594 p. ct	0.493 p. ct	0.375 p. ct	0.425 p. ct	0.350 p. ct.
Amount of coloring added	4 ounces	4 ounces	4.4 ounces	4.4 ounces	4.5 ounces	4.5 ounces	4 ounces	4 ounces	4 ounces	4 ounces.
Temperature of churning	54° F	54° F	54° F	54° F	57° F	56° F	57° F	55° F	54° F	55° F.
Time for churning	30 min	1 h	35 m	1 h. 5 m	30 m	50 m	32 m	32 m	50 m	47 m.
Wash water used	50 gallons	50 gallons	50 gallons	50 gallons	50 gallons	50 gallons	50 gallons	50 gallons	50 gallons	50 gallons.
Temperature of wash water	54° F	54° F	54° F	54° F	57° F	56° F	53° F	53° F	53° F	53° F.
Salt added	25 pounds	25 pounds	23 pounds	23 pounds	22 pounds	25 pounds	22 pounds	28 pounds	28 pounds	22 pounds.
Revolutions worked	18	19	25	25	18	16	18	18	18	18.

	1 A L.	1 A H.	1 B L.	1 B H.	2 A L.	2 A H.	2 B L.	2 B H.	3 A L.	3 A H.	3 B L.	3 B H.	4 A L.	4 A H.	4 B L.	4 B H.	5 A L.	5 A H.	5 B L.	5 B H.
Salt added ......pounds		16		16		15		15		12		10		18		20		18		20
Revolutions worked		11		11		10		10		7		7		6		9		6		9
Analysis:																				
Moisture ......per cent	12.60	12.95	12.82	13.12	15.30	14.74	14.43	14.63	12.42	12.80	12.05	12.00	15.00	13.07	12.68	13.59	11.59	12.59	13.03	13.12
Salt ......do	1.02	3.20	1.10	2.87	2.00	3.16	1.52	3.28	1.78	4.83	1.51	3.72	1.80	3.61	1.46	4.65	1.60	2.38	1.32	3.16
Fat ......do	85.09	82.63	85.01	83.01	81.30	80.97	82.64	80.61	84.53	80.80	85.27	83.24	82.38	82.22	85.22	81.27	84.95	84.64	84.96	83.26
Solids not salt or fat.do	1.29	1.22	1.07	1.00	1.40	1.13	1.41	1.48	1.27	1.57	1.17	1.04	.82	1.10	.64	.49	1.86	.39	.69	.46

PACKING.

The tubs in which the butter was packed were of spruce, all being thoroughly steamed and paraffined inside before packing. Tubs of 20 pounds capacity were used in packing butter from lots 1, 2, and 3, and tubs of 25 pounds capacity in packing butter from lots 4 and 5. All cans were made of the best quality of tin. Cans of the so-called 3-pound capacity, however (those in which butter from lots 1, 2, and 3 was packed), when full held 3¼ pounds. Cans in which butter from lots 4 and 5 was packed held when full exactly 3 pounds.

From each kind of butter made from lots of cream 1, 2, and 3 there were packed 9 tubs, holding 20 pounds each; 12 cans, 3¼ pounds each; 12 cans partly full, 3 pounds each; 12 cans partly full, 2½ pounds each; and from each kind of butter from lots 4 and 5 there were packed 9 tubs of 25 pounds each, 12 cans of 3 pounds each, and 12 cans partly full, 2½ pounds each, making in all 180 tubs, containing 3,960 pounds, 624 cans, containing 1,788 pounds, a total of 5,748 pounds of butter. Cans, partly full were used to note the effect of air on the keeping qualities of the butter.

STORAGE.

The butter from lots of cream 1, 2, and 3 was held at a temperature of + 32° F. from July 2 until July 18, when it was shipped by refrigerator freight to the storage rooms, where it arrived in good condition without having become warm. The butter from lots 4 and 5 was held at a temperature of about 40° F. from July 11 until July 20, when it was shipped by refrigerator freight to the storage rooms, arriving July 21 and being placed in storage July 22.

Four different storage rooms were used, one held at −10° F., a second at +10° F., a third at +32° F., and a vestibule having a variable temperature. The records, as kept by recording thermometers, indicate that there was very little variation in the temperatures of the first three rooms. A recording thermometer in the vestibule shows variations of temperature from 20° to 65° F. However, the greater part of the time the temperature was between 30° and 50° F.

Three tubs, 3 full cans, and 3 partly full cans from each kind of butter were placed in the room at −10° F., the same kind and number of packages in the room at +10° F., and the same in the room at +32° F. Cans similar to those placed in the other rooms, but no tubs, were stored in the vestibule. The object in storing triplicate packages at each temperature was to furnish butter for the three scorings.

SCORING.

The butter was scored by Prof. G. L. McKay, professor of dairying at the Iowa State College, and Mr. P. H. Kieffer, assistant dairy commissioner of Iowa. The first scoring was made on July 22, just

before the butter was placed in the storage room. At that time only one tub of each kind of butter was examined, it being assumed that the quality of each kind in all packages at that time was the same, the butter having been held only a short time and at low temperatures. The second scoring was made December 21 and 22, 1905, after the butter had been in storage five months. The butter scored at this time was removed December 18, 1905, from the rooms at −10°, +10°, and +32° F. and placed in the vestibule, the temperature of the vestibule at the time of scoring being 50° and 55° F. The third scoring was made March 22 and 23, 1906, after the butter had been in storage eight months. The butter scored at this time was removed from storage in Chicago March 20, 1906, and shipped by refrigerator freight to the Iowa Experiment Station, Ames, Iowa, where it was examined, as stated, on March 22 and 23, 1906.

All scores made at the times above stated, with comments as to the quality and condition of the butter at each scoring, are given in Tables II, III, IV, V, and VI.

TABLE II.—*Scores of all butter made from cream of lot No. 1, with remarks as to flavor.*

	Scored July 22, 1905, before storing.	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.		Stored at variable temperatures.	
		Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.
1 A L, containing 1.02 per cent salt:									
Tubs and cans	a 88	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	b 93	90½	c 92¼	90	a 90	86	....	....
Cans, full, 3¼ pounds	....	93¾	88	93¼	90	91	d 88½	e 80	f 80
Cans, 3 pounds	....	93¾	88	93	90	90½	88	g 77	f 80
Cans, 2½ pounds	....	91½	85	91	85	88½	86	72	80
1 A H, containing 3.20 per cent salt:									
Tubs and cans	h 89	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	90	c 88	c 89¾	i 86	h 85	j 84	....	....
Cans, full, 3¼ pounds	....	91½	90	92	89	90	88	e 85	87
Cans, 3 pounds	....	91	89½	91¼	88¾	89½	87	e 82	87
Cans, 2½ pounds	....	88	85	89½	84	84	84	e 80	80
1 B L, containing 1.10 per cent salt:									
Tubs and cans	c 91	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	93	k 91½	92	k 91¼	89	l 88	....	....
Cans, full, 3¼ pounds	....	92½	90½	92	f 87	90	f 90	f 80	m 80
Cans, 3 pounds	....	92½	90¼	91¾	87	89½	90	78	m 80
Cans, 2½ pounds	....	n 91	87	91	84	88	89	77	m 80
1 B H, containing 2.87 per cent salt:									
Tubs and cans	o 91	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	o 90½	p 87	90	p 87	88	p 87	....	....
Cans, full, 3¼ pounds	....	91½	89	91	88	89½	b 90	f 80	p 88
Cans, 3 pounds	....	91¼	88	91½	88	89	89	f 78	p 82
Cans, 2½ pounds	....	88½	87	89	82	86	87	f 73	p 82

a Very unclean; fishy; decided old cream flavor.
b Trace fishy.
c Fishy.
d Cheesy and tallowy.
e Rancid.
f Cheesy.
g Rancid and sour.
h Salt mackerel.
i Fishy; old cream.
j Fishy; very poor.
k Slightly cheesy.
l Old and stale.
m Very cheesy.
n Turpentine; old.
o Not clean; old cream.
p Stale; old cream.

TABLE III.—*Scores of all butter made from cream of lot No. 2, with remarks as to flavor.*

	Scored July 22, 1905, before storing.	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.		Stored at variable temperatures.	
		Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.
2 A L, containing 2 per cent salt:									
Tubs and cans	*a* 91½								
Tubs, 20 pounds		92½	*b* 89	*c* 89	*b* 89	*d* 91	*b* 88		
Cans, full, 3¼ pounds		93	90	92	*e* 89	92	90	*f* 90	*g* 84
Cans, 3 pounds		92½	90	91¾	*e* 89	91½	90	*f* 89½	84
Cans, 2¼ pounds		88½	82	89	*e* 87	90	80	*f* 87	*g* 84
2 A H, containing 3.16 per cent salt:									
Tubs and cans	*h* 89½								
Tubs, 20 pounds		*i* 91	*j* 89	*i* 90	*k* 88½	89	*l* 84		
Cans, full, 3¼ pounds		91	*m* 87½	91	82	90	*l* 88½	*f* 89	*n* 86
Cans, 3 pounds		90	87	90	82	89	88½	*f* 88	84
Cans, 2¼ pounds		87	80	87	78	86	70	*f* 87	84
2 B L, containing 1.52 per cent salt:									
Tubs and cans	91½								
Tubs, 20 pounds		*o* 91	*i* 88½	*i* 90½	*p* 88	*q* 88	*q* 82		
Cans, full, 3¼ pounds		91	*k* 89	90½	*o* 88	90	*e* 89	88	*r* 86
Cans, 3 pounds		90	*j* 84	90	88	90	84	86	86
Cans, 2¼ pounds		89½	84	*s* 88	82	86	84	85	84
2 B H, containing 3.28 per cent salt:									
Tubs and cans	*t* 89								
Tubs, 20 pounds		89	85	*i* 87½	85	*k* 86	80		
Cans, full, 3¼ pounds		90	*j* 86	*u* 89	85	88	87	86	86
Cans, 3 pounds		89½	85	89	84½	87½	87	85	86
Cans, 2¼ pounds		88	80	87	83	86	84	82	80

a Slightly unclean.
b Old cream; cheesy.
c Very fishy.
d Turpentine.
e Cheesy.
f Rancid.
g Very cheesy.
h Pronounced fishy; undesirable; unclean; turpentine flavor.
i Fishy.
j Fishy; old.
k Oily; fishy.
l Oily.
m Oily; fishy; old.
n Stale; old cream.
o Trace fishy.
p Oily; trace fishy.
q Rancid; trace fishy.
r Rancid; stale; cheesy.
s Rancid; turpentine.
t Strong, fishy; unclean flavor; old cream; dirty can flavor.
u Very metallic.

TABLE IV.—*Scores of all butter made from cream of lot No. 3, with remarks as to flavor.*

	Scored July 22, 1905, before storing.	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.		Stored at variable temperatures.	
		Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.
3 A L, containing 1.78 per cent salt:									
Tubs and cans	89	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	92	[a]88	[b]91½	[c]87½	[d]91½	[e]84	....	....
Cans, full, 3¼ pounds	....	92½	[f]83	92	[g]82	91	[f]87	89	[f]88
Cans, 3 pounds	....	92	83	92	[h]80	91	[f]87	88	[f]88
Cans, 2½ pounds	....	89	87	91	[h]78	91	[f]87	87	[f]88
3 A H, containing 4.88 per cent salt:									
Tubs and cans	[i]89	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	[j]88	[k]87	[j]87½	[k]85	[j]84	[j]78	....	....
Cans, full, 3¼ pounds	....	[k]90	[i]87	90	86	87	[j]86	[l]87	[m]86
Cans, 3 pounds	....	[k]87	86	89	[h]84	86½	87	85	[n]82
Cans, 2½ pounds	....	[k]84	[h]80	84	[h]78	82	88	82	[n]76
3 B L, containing 1.51 per cent salt:									
Tubs and cans	[o]89	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	92½	87	92	88	91	84	....	....
Cans, full, 3¼ pounds	....	92	87	91½	[f]87	90	[e]86	[p]89	[f]85
Cans, 3 pounds	....	92	87	91½	[f]87	90	[e]86	88	[f]85
Cans, 2½ pounds	....	[q]89½	80	90	[f]84	89	[e]84	86	[f]85
3 B H, containing 3.72 per cent salt:									
Tubs and cans	[r]89	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	[k]87	[h]85	86	[h]85	82	84	....	....
Cans, full, 3¼ pounds	....	88	[h]85	87	[h]85	85	[s]84	86	[l]88
Cans, 3 pounds	....	88	[h]85	87	[h]85	85	[s]84	86	86
Cans, 2½ pounds	....	84	[h]83	86	[h]83	82	82	84	[n]80

[a] Oily; fishy; cheesy.
[b] Sour.
[c] Oily; cheesy.
[d] Turpentine.
[e] Very cheesy.
[f] Cheesy.
[g] Cheesy; stale.
[h] Very poor.
[i] Salt mackerel.
[j] Very fishy.
[k] Fishy.
[l] Oily.
[m] Old; stale.
[n] Oily; fishy.
[o] Not clean.
[p] Old; rancid.
[q] Metallic.
[r] Weedy.
[s] Fishy; very poor.

TABLE V.—*Scores of all butter made from cream of lot No. 4, with remarks as to flavor.*

	Scored July 22, 1905, before storing.	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.		Stored at variable temperatures.	
		Scored Dec. 22, 1905.	Scored Mar. 22, 1906.	Scored Dec. 22, 1905.	Scored Mar. 22, 1906.	Scored Dec. 22, 1905.	Scored Mar. 22, 1906.	Scored Dec. 22, 1905.	Scored Mar. 22, 1906.
4 A L, containing 1.80 per cent salt:									
Tubs and cans	[a]95½	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	93½	[b]93½	93½	93	[c]89	91	....	....
Cans, full, 3 pounds	....	93	92	[d]91½	93	91	88	89	[e]82
Cans, 2½ pounds	....	93	90	91½	[f]84	[g]88	84	86	[e]82
4 A H, containing 3.60 per cent salt:									
Tubs and cans	[h]94	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	[i]92	[c]92½	[j]91½	92½	[f]89	[k]88	....	....
Cans, full, 3 pounds	....	91½	92½	91	86	89	85	[l]86	90
Cans, 2½ pounds	....	91½	92	91	[m]85	87	80	[l]84	80
4 B L, containing 1.46 per cent salt:									
Tubs and cans	[n]97	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	[b]94	[n]93½	93½	93	[o]90	86	....	....
Cans, full, 3 pounds	....	95½	92	[d]92½	93	89½	90	[e]87	86
Cans, 2½ pounds	....	93	92	[d]92	92	88	90	[p]84	84
4 B H, containing 4.65 per cent salt:									
Tubs and cans	[q]95	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	93	93	92½	93	[m]89½	88	....	....
Cans, full, 3 pounds	....	92¼	92	92½	92	[r]89	85	[l]88	86
Cans, 2½ pounds	....	92½	91	91½	88	[r]87	81	[l]84	83

[a] Slightly flat.
[b] Very good.
[c] Oily; trace fishy.
[d] Metallic.
[e] Cheesy.
[f] Fishy; oily.
[g] Rancid; old.
[h] Sweet but flat.
[i] Trace fishy.
[j] Stale, trace fishy.
[k] Very fishy.
[l] Rancid.
[m] Fishy.
[n] Very clean but not pronounced.
[o] Old; stale.
[p] Very cheesy.
[q] Brine flavor; butter flavor not pronounced.
[r] Fishy; stale.

TABLE VI.—*Scores of all butter made from cream of lot No. 5, with remarks as to flavor.*

	Scored July 22, 1905, before storing.	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.		Stored at variable temperatures.	
		Scored Dec. 22, 1905.	Scored Mar. 22, 1906.	Scored Dec. 22, 1905.	Scored Mar. 22, 1906.	Scored Dec. 22, 1905.	Scored Mar. 22, 1906.	Scored Dec. 22, 1905.	Scored Mar. 22, 1906.
5 A L, containing 1.60 per cent salt:									
Tubs and cans	*a* 94½	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	92	*b* 93½	92	93½	*c* 90	90	....	....
Cans full, 3 pounds	....	92	93	92	*d* 91	*c* 90	*e* 88	84	*f* 85
Cans, 2½ pounds	....	*d* 92	91	*d* 91½	88	*g* 88	80	80	*f* 85
5 A H, containing 2.38 per cent salt:									
Tubs and cans	*h* 94½	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	91½	93	*i* 92	93	*o* 88	91	....	....
Cans full, 3 pounds	....	*d* 91	93	92	*j* 90	89½	*k* 88	78	85
Cans, 2½ pounds	....	*d* 90½	90	90	87	84	82	73	88
5 B L, containing 1.32 per cent salt:									
Tubs and cans	*l* 97	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	93	94	93	93	*m* 91	90	....	....
Cans full, 3 pounds	....	*n* 93	93½	*n* 93	*d* 91½	80	90	86	80
Cans, 2½ pounds	....	93	92	92½	91½	86	90	80	78
5 B H, containing 3.16 per cent salt:									
Tubs and cans	*o* 95½	....	....	....	....	....	....	....	....
Tubs, 20 pounds	....	93	*p* 93	*i* 93	92¾	*q* 90½	90	....	....
Cans full, 3 pounds	....	93	93½	*d* 92½	91½	*r* 89½	88½	86	90½
Cans, 2½ pounds	....	93	90½	92	91½	88	82	82	89½

a Slightly cooked; tallowy; shows age.
b Very good; fresh.
c Fishy.
d Metallic.
e Cheesy.
f Very cheesy.
g Very fishy.
h Weedy.
i Trace fishy.
j Oily; fishy.
k Oily.
l Exceptionally good.
m Shows age.
n Trace metallic.
o Cooked flavor.
p Clean but flat.
q Trace fishy; old; stale.
r Fishy; metallic.

A number of variations in scores may be noted in Tables II, III, IV, V, and VI, and in order that these variations may be studied with greater ease other tables are presented.

EFFECT OF SALT.

The scores in Table VII are from butter in tubs, there being no material difference between the scores of butter in tubs and in cans, as will be shown.

TABLE VII.—*Scores of all butter in tubs, with averages showing differences attributed to percentage of salt.*

	Per cent of salt.	Scores.						
		Before storing.	Stored at —10° F.		Stored at +10° F.		Stored at +32° F.	
			Five months.	Eight months.	Five months.	Eight months.	Five months.	Eight months.
1 A L	1.02	88	93	90½	92¼	90	90	86
1 A H	3.20	89	90	88	89¾	86	85	84
1 B L	1.10	91	93	91½	92	91¼	89	88
1 B H	2.87	91	90½	87	90	87	88	87
2 A L	2.00	91½	92½	89	89	89	91	88
2 A H	3.16	89½	91	89	90	88½	89	84
2 B L	1.52	91½	91	88½	90½	88	88	82
2 B H	3.28	89	89	85	87½	85	86	80
3 A L	1.78	89	92	88	91¾	87½	91½	84
3 A H	4.83	89	88	87	87½	85	84	78
3 B L	1.51	89	92½	87	92	88	91	84
3 B H	3.72	89	87	85	86	85	82	84
4 A L	1.80	95½	93½	93½	93½	93	89	91
4 A H	3.61	94	92	92½	91½	92½	89	88
4 B L	1.46	97	94	93½	93½	93	90	86
4 B H	4.65	95	93	93	92½	93	89½	88
5 A L	1.60	94½	92	93½	92	93½	90	90
5 A H	2.38	94½	91½	93	92	93	88	91
5 B L	1.32	97	93	94	93	93	91	90
5 B H	3.16	95½	93	93	93	92¾	90½	90
Averages of lots 1, 2, 3, 4, and 5:								
A L	1.64	91.7	92.6	90.9	91.70	90.60	90.3	87.8
A H	3.44	91.2	90.5	89.9	90.15	89.00	89.0	85.0
Difference	−1.80	.5	2.1	1.0	1.55	1.60	3.3	2.8
B L	1.38	93.1	92.7	90.9	92.20	90.65	89.8	86.0
B H	3.54	91.9	90.5	88.6	89.70	88.55	87.2	85.8
Difference	−2.16	1.2	2.2	2.3	2.50	2.10	2.6	.2
Average of both scorings, lots 1, 2, 3, 4, and 5:								
A L	1.64	....	91.75		91.15		89.05	
A H	3.44	....	90.20		89.57		86.00	
Difference	−1.80	....	1.55		1.58		3.05	
B L	1.38	....	91.80		91.42		87.90	
B H	3.54	....	89.55		89.12		86.50	
Difference	−2.16	....	2.25		2.30		1.40	

In comparing the first two scores in the foregoing table, butter 1 A L and 1 A H, it should be remembered that this butter was from the same churning, but with different percentages of salt, the percentage in 1 A H being 3.20 and in 1 A L 1.02, a difference of 1.18. The scores before storing were 88 and 89, one point in favor of 1 A H, the butter with the greater percentage of salt. The tubs of this butter held at −10° F. scored after five and eight months 3 points and 2½ points, respectively, in favor of the lightly salted butter. Tubs of the same butter held at +10° F. after five and eight months scored,

respectively, 2½ points and 4 points in favor of the light salting. The same butter at +32° F. after five and eight months scored, respectively, 5 points and 2 points in favor of the light salting.

Comparing scores of 5 B L and 5 B H, butter from the same churning containing 1.32 and 3.16 per cent of salt, respectively, or a difference of 1.84 per cent, it will be noted that the scores after five months were exactly the same for butter at −10° and +10° F. After eight months there was a slight difference in favor of light salting. Butter 5 B H when placed in storage scored the highest of the butter with heavy salting, and seemed to have been the least affected by the salt. Throughout the table it will be noted that the butter having the higher score when placed in storage shows the least effect of heavy salting. This being true, it seems that the practice of attempting to cover up undesirable flavors in poor butter by using a large percentage of salt, if butter is stored, would produce results in the opposite direction to those desired.

The average of all scores of butter from unpasteurized cream with light salting compared with the average of the scores of the same butter with heavy salting shows the following:

Difference in percentages of salt, 1.80. Differences in scores of butter held at −10° F. after five and eight months, 2.1 points and 1 point, respectively, in favor of light salting. Average of both scorings, 1.55 points in favor of light salting.

The same butter stored at +10° F. after five and eight months showed, respectively, 1.55 and 1.60 points in favor of light salting. Average of both scorings, 1.57 points.

The same butter stored at +32° F. after five and eight months showed 3.3 and 2.8 points, respectively, in favor of light salting, or an average of 3.05 points.

The average of scores of all butter from pasteurized cream with light salting compared with average scores of the same butter with heavy salting shows a difference in the percentage of salt of 2.16.

Scores of butter at −10° F. after five and eight months show a difference of 2.2 and 2.3 points, respectively, in favor of light salting, or an average of 2.25 points.

The same butter stored at +10° F. after five and eight months shows a difference of 2.5 and 2.1 points, respectively, in favor of light salting, or an average of 2.3 points.

The same butter stored at +32° F. after five and eight months shows a difference of 2.6 and 0.2 points, respectively, in favor of light salting, or an average of 1.40 points.

The only scores indicating that heavy salting was of any advantage were those of the butter held in cans eight months at variable temperatures.

KEEPING QUALITIES OF BUTTER IN FULL CANS AND TUBS.

TABLE VIII.—*Comparison of average scores of butter in full cans and tubs.*

	Scores.					
	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.	
	Five months.	Eight months.	Five months.	Eight months.	Five months.	Eight months.
Averages, lots 1, 2, 3, 4, and 5:						
A L in full cans	92.85	89.2	92.15	89.0	91.0	88.3
A L in tubs	92.60	90.9	91.70	90.6	90.3	87.8
Difference in favor of cans	.25	−.7	.45	−.4	.7	.5
Average difference of both scorings	−.22		.025		.6	
A H in full cans	91.0	90.0	91.20	86.6	89.1	87.1
A H in tubs	90.5	89.9	90.15	89.0	87.0	85.0
Difference in favor of cans	.5	.1	1.05	−2.4	2.1	2.1
Average difference of both scorings	.3		−.69		2.1	
B L in full cans	92.4	90.4	91.9	89.30	89.9	89.0
B L in tubs	92.7	90.9	92.2	90.65	89.8	86.0
Difference in favor of cans	−.3	−.5	−.3	−1.35	.1	3.0
Average difference of both scorings	−.4		−.82		1.55	
B H in full cans	90.95	89.1	90.4	88.30	88.2	86.9
B H in tubs	90.50	88.6	89.7	88.55	87.2	85.8
Difference in favor of cans	.45	.5	.7	−.25	1.00	1.1
Average difference of both scorings	.47		.22		1.05	

Comparing the figures in the foregoing table, the average scores of tubs and full cans of A L (pasteurized cream, lightly salted) butter, it will be seen that the butter of five months at −10°, +10°, and +32° F. scored, respectively, 0.25, 0.45, and 0.7 point in favor of cans. After eight months, at −10° and +10° F., scores show 0.7 and 0.4 point, respectively, in favor of tubs, while at +32° F. scores show 0.5 point in favor of cans. The average of both scorings shows for butter held at −10° F. 0.22 point in favor of tubs, and for butter at +10° and +32° F., 0.025 and 0.6 point, respectively, in favor of cans.

Comparing the average scores from A H (unpasteurized cream, heavily salted) butter, after five months at −10°, +10°, and +32° F., the scores show 0.5, 1.05, and 2.1 points in favor of cans. After eight months at +10° F. the scores show 2.4 points in favor of tubs, and at −10° and +32° F. 1 and 2.1 points, respectively, in favor of cans; averages of both scorings showing at −10° and +32° F. 3 and 2.1 points, respectively, in favor of cans, and at +10° F. 0.69 point in favor of tubs.

With B L (pasteurized cream, lightly salted) butter all scores at −10° and +10° F. were slightly in favor of tubs, while at +32° F. butter in cans received an average score a trifle higher than that of the butter in tubs.

Comparing the average scores of B H (pasteurized cream, lightly

salted) butter, all average scores, excepting those of butter held eight months at +10° F., were in favor of cans.

Comparing all scores of butter in tubs with all scores of butter in cans at −10° and +10° F., no material difference is noted. At 32° F. there is a very slight difference in favor of cans.

EFFECT OF AIR IN CANS.

TABLE IX.—*Comparison of average scores of butter in full cans and in partly full cans.*

	Scores.							
	Stored at —10° F.		Stored at + 10° F.		Stored at + 32° F.		Stored at variable temperatures.	
	Five months.	Eight months.	Five months.	Eight months.	Five months.	Eight months.	Five months.	Eight months.
Averages, lots 1, 2, 3, 4, and 5:								
A L in full cans	92.85	89.2	92.15	89.0	91.0	88.3	86.4	83.8
A L in cans partly full, 2¼ pounds	90.80	87.0	90.80	84.4	89.1	83.4	82.4	83.8
Difference in favor of full cans	2.05	2.2	1.35	4.6	1.9	4.9	4.0	.0
Average difference of both scorings	2.12		2.97		3.4		2.0	
A H in full cans	91.0	90.0	91.2	86.6	89.1	87.1	85.0	86.0
A H in cans partly full, 2¼ pounds	88.6	85.4	88.3	82.4	84.6	80.8	81.2	81.6
Difference in favor of full cans	2.4	4.6	2.9	4.2	4.5	6.3	3.8	5.4
Average difference of both scorings	2.9		3.55		5.4		4.6	
B L in full cans	92.4	90.4	91.9	89.3	89.9	89.0	85.8	83.4
B L in cans partly full, 2¼ pounds	91.2	87.0	90.7	86.7	87.4	87.4	82.4	82.2
Difference in favor of full cans	1.2	3.4	1.2	2.6	2.5	1.6	3.4	1.2
Average difference of both scorings	2.3		1.9		2.05		2.3	
B H in full cans	90.95	89.1	90.4	88.3	88.2	86.9	85.2	86.7
B H in cans partly full, 2¼ pounds	89.20	86.3	89.1	85.5	85.8	83.1	81.0	82.9
Difference in favor of full cans	1.75	2.8	1.3	2.8	2.4	3.8	4.2	3.8
Average difference of both scorings	2.27		2.05		3.1		4.0	

Comparing the average scores of butter in full cans and in partially full cans it will be noted that there were differences of 1 to 5 points in favor of the full cans. It does not seem necessary to take up these differences in detail. This deterioration was without doubt due to air in the partially full cans. Since in packing butter in cans there is no necessity for having the cans only partially full, neither is this economical, the writer does not hesitate to state that where the sealing is done at atmospheric pressure the cans should be entirely filled, leaving as little air space as possible. This principle may be applied to packing butter in other packages. The butter should be packed solidly, leaving

as few air spaces as possible. Air having a deteriorating effect on the keeping of storage butter, it would be expected that butter stored in small open packages, as pound prints, would not keep so well as butter in large packages. This is a belief that has already been accepted by many.

EFFECT OF STORAGE TEMPERATURES.

TABLE X.—*Scores of butter stored at −10° F. compared with those of butter stored at +10° F., +32° F., and at variable temperatures.*

	Average scores.				
	A L butter.	A H butter.	B L butter.	B H butter.	Average difference.
Butter in tubs:					
−10° F.	91.75	90.20	91.80	89.55	
+10° F.	91.15	89.57	91.42	89.12	
Difference in favor of −10° F.	.60	.63	.38	.43	.51
−10° F.	91.75	90.20	91.80	89.55	
+32° F.	89.05	86.00	87.90	86.50	
Difference in favor of −10° F.	2.70	4.20	3.90	3.05	3.46
Butter in full cans:					
−10° F.	91.02	90.50	91.40	90.02	
Variable.	85.10	85.50	84.60	85.95	
Difference in favor of −10° F.	5.92	5.00	6.80	4.07	5.45

Table X was prepared from average scores which have been given in previous tables. The difference in quality of all butter held in tubs at −10° and +10° F., as shown by average scores, was 0.51 point in favor of the butter held at a temperature of −10° F. The difference in quality of all butter held in tubs at −10° and +32° F. was, as shown by average scores, 3.46 points in favor of the butter held at −10° F. The difference in the quality of the butter in full cans held at −10° F. and at variable temperatures was, as shown by average scores, 5.45 points in favor of the butter held at −10° F.

KEEPING QUALITIES AFTER REMOVAL FROM STORAGE.

Results thus far given practically show only the changes which took place while the butter was in storage, the butter being out of storage only long enough to thaw before scoring. Another matter of as great importance as the keeping qualities of butter when in storage is the keeping qualities of butter after its removal from storage. The butter should be in good condition when it reaches the consumer, and remain good a reasonable length of time. One week would certainly be the minimum, and in many cases the time would be much longer. The butter scored December 21 and 22, 1905, could not be scored a second time without considerable inconvenience. The butter scored March 22 and 23, 1906, was allowed to remain out of cold storage, and the butter in tubs was again scored April 2. The butter was scored at that time by Professor McKay alone, as Mr. Kieffer could not be present. These scores are given in Table XI.

TABLE XI.—*Showing deterioration of storage butter after removal from storage.*

Butter in tubs.	Before storing.	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.	
		Scored Mar. 22, 1906.	Scored Apr. 2, 1906.	Scored Mar. 22, 1906.	Scored Apr. 2, 1906.	Scored Mar. 22, 1906.	Scored Apr. 2, 1906.
1 A L	88	90½	75	90	74	86	Very bad.
1 A H	89	88	73	86	72	84	Very bad.
1 B L	91	91½	75	91½	74	88	Very bad.
1 B H	91	87	73	87	72	87	Very bad.
2 A L	91½	89	75	89	75	88	Very bad.
2 A H	89½	89	77	88½	76	84	Very bad.
2 B L	91½	88½	74	88	73	82	Very bad.
2 B H	89	85	75	85	75	80	Very bad.
3 A L	89	88	81	87½	79	84	Very bad.
3 A H	89	87	76	85	76	78	Very bad.
3 B L	89	87	75	88	74	84	Very bad.
3 B H	89	85	75	85	75	84	Very bad.
4 A L	95½	93½	92½	93	90½	91	80
4 A H	94	92½	90½	92½	90	88	80
4 B L	97	93½	93	93	90½	86	82
4 B H	95	93	92	93	91	88	84
5 A L	94½	93½	92	93½	91	90	80
5 A H	94½	93	91	93	90	91	82
5 B L	97	94	93½	93	92½	90	83
5 B H	95½	93	92½	92¾	91	90	85
Average of above scores of butter from lots 4 and 5	95.37	93.25	92.12	92.97	90.81	94.25	....
Average of above scores of butter from lots 1, 2, and 3	89.70	87.96	75.33	87.51	74.58	84.08	....
Average difference in favor of butter from lots 4 and 5	5.67	5.29	16.79	6.46	16.23	5.17	....

In Table XI, besides the scores of April 2, the scores of March 22 and 23 and those before storing are given. By studying carefully the scores of April 2 differences will be found which may be attributed to salt and temperature. These differences in the butter held at −10° and +10° F. are about the same or perhaps greater than have been noted in previous tables. There are other differences so much greater that those attributed to salt and temperature seem of minor importance.

Looking at the scores of April 2, 1906, it is noted that all scores of butter from the first three lots of cream are very low, while those of the butter from lots 4 and 5 are only about 1 point lower than the scores of the same butter ten days previously. To determine more readily the difference in scores between the butter made from the first three lots of cream and that from the last two lots two averages have been made. These show that the average score of all butter from lots 4 and 5 when first scored was 95.37, while the average score of all butter from lots 1, 2, and 3 was 87, being 5.67 points lower. The average score of all butter from lots 4 and 5, after being in storage at −10° F. eight months, was 93.25. After the butter had been out of storage ten days the average score was 92.12, only 1.13 points lower. The average score of all butter from lots 1, 2, and 3, after being in storage at −10° F. eight months, was 87.96. After the butter had been out of storage ten days the average score was 75.33, or 12.63 points lower, showing that the deterioration of the butter from lots 1, 2, and 3 was more than ten times as great as that from lots 4 and 5. The rate of deterioration of butter held at +10° F. was practically the

same as has just been noted for the butter held at −10° F. The deterioration of all butter held at +32° F. was very marked.

In endeavoring to account for these differences in keeping quality, which have divided the butter into two classes, the first question probably would be, How and from what kind of cream was each class of butter made? For this information we may refer to Table I. As has previously been noted, cream of lots 1, 2, and 3 was sour when received, showing acidities of 0.560, 0.575, and 0.558 per cent, respectively, or between 31 and 32 c. c., Mann's test. The cream in lots 4 and 5 was of good quality and perfectly sweet. The acid development in lots 1, 2, and 3 from the time received until churned was very little, owing to the cream being practically ripe when received. With lots 4 and 5 the percentage of acid developed was not high. In fact, this cream at the time of churning had lower percentages of acid than had lots 1, 2, and 3 when received. Other than these points just mentioned there was practically no difference in the making of the butter. The butter from lots 1, 2, and 3 was held about ten days longer before being placed in storage than was butter from lots 4 and 5; however, it being held at +32° F., the writer is of the opinion that this length of time would not make any material difference. There is without doubt a direct relation between the differences in the cream as shown in Table I and the differences in the keeping qualities of the butter after removal from storage, as shown in Table XI.

SUMMARY.

The results thus far obtained in this investigation may be summarized as follows:

(1) Butter containing low percentages of salt kept better than did butter of the same lot containing higher percentages of salt.

(2) Butter in full cans and tubs at −10° and +10° F. scored about the same. At +32° F. there was a slight difference in favor of cans.

(3) Butter in full cans kept much better than did butter in cans only partially full, the deterioration doubtless being due to the presence of air in the partially full cans.

(4) Butter held at −10° F. kept best, both when in storage and after removal from storage.

(5) Butter made from cream received at the creamery sweet and in good condition kept well while stored at −10° and +10° F.; also after removal from storage, giving results wholly satisfactory.

(6) Butter made from cream received at the creamery sour and in fair condition kept well while in storage at −10° and +10° F., but deteriorated rapidly after removal from storage, giving, on the whole, results which were very unsatisfactory.

REMARKS ON THE SCORING OF THE BUTTER.

By G. L. McKay.

It was the writer's privilege to officiate as judge in conjunction with Mr. P. H. Kieffer, assistant dairy commissioner of Iowa. The judges had no intimation in any of the scorings as to how the different lots were made. The work was all outlined by Mr. Gray and the records were kept in his possession until all scorings were completed, so that there was nothing to influence the judges one way or the other. When the scoring was completed it was found that the butter made from cream received sour scored higher on the second scoring than the first. This was undoubtedly due to many of the odors not being so apparent when the butter was cold or chilled. It has been asserted by some butter merchants in the past that butter made from real sour cream comes out of storage better than that made from mildly acid cream. This impression is undoubtedly due to the undesirable odors not being manifest when the butter was chilled or held in storage for some time. On the final scoring, however, after this butter had stood at a high temperature for some days the butter made from sour cream went off flavor very rapidly, as indicated by the scores.

Another noticeable feature, both in the tubs and in the hermetically sealed cans, was that the fishy flavor was quite pronounced in those lots made from old cream where a high percentage of salt had been used. The high percentage of salt seemed to bring out latent odors and make them more pronounced.

At the second and third scorings it was found that the different lots of butter kept at high temperatures did not have so decided a fishy flavor as the butter held at lower temperatures, as other flavors had now developed which covered up the fishy flavors. The high salting did not impart a fishy flavor to the butter made from cream received sweet, so it would seem to the writer that the odors are in the butter, and the salt simply makes them more pronounced.

It was noticed with regard to the hermetically sealed cans that in the case of those only partly filled, thus having an air space, the butter scored much lower than in the full cans. Mr. Gray had so varied the amount of butter in these cans that different-sized air spaces were left. In some instances where the amount of butter in the can was the smallest and the butter was somewhat loose, thus permitting the air to come in contact with a great portion of it, the quality was much inferior to that of butter tightly packed.

The lightly salted butter held at -10° F. seemed to be almost as fresh at the second scoring as new or freshly made butter.

The fourth scoring was made twelve days after the butter had been taken out of storage and had been for ten of these days kept in an ordinary room at a temperature of about 60° F. At this point all the butter made from cream received sour had deteriorated so much that it was practically packing stock, while that made from cream received sweet, salted lightly, and kept at a low temperature up to the time of leaving the storage room, scored nearly as high at the third scoring.

The lightly salted butter held at the higher temperatures, had a tendency to develop what is known as a cheese flavor. In lots held at $+32^\circ$ F. and above, the cheese flavor seemed to give way to a turpentine or paint flavor at the third scoring. The butter held at -10° F., both in high and low saltings, was more free from foreign odors than that held at $+10^\circ$ F.

It seems to the writer, from his work in scoring the butter and after examining the records kept by Mr. Gray, that light salting and low temperatures gave much the best results for storage butter.

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CONTROL AND ERADICATION OF CONTAGIOUS DISEASES.

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Dr. R. A. Ramsay, room 320 Quincy Building, Denver, Colo., in general charge of eradication of scabies of sheep and cattle in the West.
Albuquerque, N. Mex.—Dr. Louis Metsker, room 22 N. T. Armijo Building.
Denver, Colo.—Dr. Lowell Clarke, room 320 Quincy Building.
Fargo, N. Dak.—Dr. R. H. Treacy.
Kansas City, Kans.—Albert Dean, room 328 Live Stock Exchange.
Salt Lake City, Utah.—George S. Hickox, room 21 Eagle block.

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New York, N. Y.—Dr. W. H. Rose, 18 Broadway.
Norfolk, Va.—Dr. G. C. Faville, P. O. box 796.
Philadelphia, Pa.—Dr. C. A. Schaufler, 134 South Second street.
Portland, Me.—Dr. F. W. Huntington, U. S. customs office, Grand Trunk R. R. wharf.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY.—BULLETIN No. 85.
A. D. MELVIN, CHIEF OF BUREAU.

INVESTIGATIONS IN THE MANUFACTURE AND CURING OF CHEESE.

VI.—THE COLD CURING OF AMERICAN CHEESE,

WITH A DIGEST OF PREVIOUS WORK ON THE SUBJECT.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., May 10, 1906.

Sir: I have the honor to transmit herewith a manuscript entitled "The Cold Curing of American Cheese," by C. F. Doane, expert in charge of cheese investigations of the Dairy Division of this Bureau. This paper, which is one in a series on Investigations in the Manufacture and Curing of Cheese, contains a report of recent experiments by the Dairy Division, prefaced by a review of previous work in cold curing. In view of the undoubted value of this information for the cheese industry of the country I recommend its publication as a bulletin of this Bureau.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

INTRODUCTION.

This bulletin is the sixth in a series on Investigations in the Manufacture and Curing of Cheese. The previous numbers, which were issued under separate titles and not given the general title or special numerical designations now adopted for the series, are as follows:

I. The Cold Curing of Cheese. Bulletin No. 49.

II. The Relation of Bacteria to the Flavors of Cheddar Cheese. Bulletin No. 62.

III. The Camembert Type of Soft Cheese in the United States. Bulletin No. 71.

IV. Fungi in Cheese Ripening: Camembert and Roquefort. Bulletin No. 82.

V. The Cold Storage of Cheese. Bulletin No. 83.

The work to be reported in this series will consist of investigations in the manufacture and curing of American, or Cheddar, cheese and in the manufacture and adaptation to American conditions of the more important European varieties of cheese.

The present bulletin treats of the effect of different low temperatures of storage, and the time of putting into storage, on the curing of American or Cheddar cheese and includes a digest of all previous work on this subject. The experiment herein reported was inaugurated to study, under factory conditions and on a commercial basis, the problems of temperature in curing and storage. This plan made it possible to use larger quantities of cheese than had ever before been used in work of this kind.

The author of the bulletin, Mr. C. F. Doane, dairy expert in charge of the cheese section of the Dairy Division, planned and executed the work in all its details. The cheese was made in a large commercial factory near Plymouth, Wis., and the storage or curing experiment was carried on at a cheese-storage warehouse at Plymouth, in rooms specially built and equipped for the work.

ED. H. WEBSTER,
Chief of Dairy Division.

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INVESTIGATIONS IN THE MANUFACTURE AND CURING OF CHEESE.

THE COLD CURING OF AMERICAN CHEESE.

PRELIMINARY REMARKS.

There is a general opinion of long standing that it is necessary for cheese to go through a ripening or breaking-down process before it is fit for human food. The green cheese as it comes from the press has a consistency much like that of india rubber and feels somewhat like that substance to the touch. In addition there are certain physiological effects popularly supposed to follow the eating of green curd as it comes from the vat, and this supposition has grown into a belief on the part of both scientist and layman that the green cheese is partially if not almost wholly indigestible. These opinions, which will very likely be shown to have little foundation in fact, made it seem desirable that the cheese should go through a ripening or breaking-down process before it reached the hands of the retail dealer and consumer. But it is not the purpose in this bulletin to go into any discussion of the changes that occur during this ripening period; they are very complicated, are probably due to a number of disputed causes, and are evidently not thoroughly understood by scientists in general.

The outward evidence that this ripening has progressed to a supposedly sufficient extent is a change in the physical condition of the cheese, in which the curd loses its elastic consistency and becomes friable and waxy to the touch and somewhat soluble in water. During this process, when carried through under old factory conditions, there is also a decided change in the flavor. The flat and insipid taste of the green curd disappears, and the product acquires a characteristic cheesy flavor, which becomes strong and sharp as the ripening progresses.

As will be discussed in greater detail later, a decided change has evidently taken place in the tastes and desires of the consumer along this line. The market is progressing toward a milder cheese, and this change has evidently come with the new ideas in regard to curing. Under the old system of warm curing rooms the consumer had very little chance to become acquainted with anything but a product well broken down in texture and highly developed in flavor. While it is

hard to predict the future course of the consumer's taste in this connection, it is very doubtful if we shall ever arrive at the time or condition when as a general thing some flavor is not desired in the cheese. This comparative demand for mild or for strong cheese is very naturally of considerable interest in connection with any question concerning methods and conditions of curing. Especially is this true in the discussion of methods which are likely to cause a great variation in the flavor of the product. The old system of warm rooms developed a high flavor; the new system of cold rooms has a tendency to suppress flavor entirely. To ascertain the public taste and meet it by modifications will probably prove to be almost a necessity in the cheese-curing industry.

In the American or Cheddar cheese industry of the present time there are two very important practical questions, one of recent origin and the other recognized for several years. These are so closely related that it is almost impossible to consider them separately, as they depend to a great extent upon each other. The recent question has already been mentioned, and relates to the growth of the popular demand for mild cheese; the other is the problem of the influence of temperature on the curing of cheese, which has been studied for about ten years and which has a number of points that have not yet been settled to the satisfaction of cheese dealers in general.

In the early days of the industry in this country not much attention was paid to the question of the effect of temperature on curing. The curing rooms or "dry houses," as they were called, had very little or no provision against changes in temperature, and it is probable that the temperature followed closely that of the outside atmosphere. The practice of winter cheese making is of comparatively recent origin, so that there was, as a rule, no necessity for any provision against the freezing of the product. Heat was not supposed to have any effect in the curing—it would at least so appear from a description of the old curing rooms—and consequently no attempt at insulation was made. It was not until 1895 that this question of curing-room temperature was considered of sufficient importance to warrant any attempt being made to determine if any benefit could be derived from the employment of an artificial temperature lower than the temperature prevailing during a large part of the summer. It is somewhat astonishing that this should have been the case, as at the present time it is so well recognized that the effects of high temperature on cheese are plainly unfavorable that we do not understand why the cheese maker of twenty or thirty years ago should not have perceived this and tried to remedy it. We know that where a cheese has any tendency whatever to a gassy nature the heat immediately causes it to swell or huff up to an extent causing considerable damage to its commercial value. We also know that the heat causes the grease to come out of the

cheese, and that it has a tendency to develop any latent undesirable flavors; in fact, there are but few respects in which heat does not have an unfavorable influence. And yet it would appear that the cheese maker of those days entirely overlooked these things. It is likely that he considered these evils as more the result of the season than the effect of any conditions that were within his control.

The first scientific theories worthy of consideration in connection with the curing process did not tend to help matters to any extent. As soon as the science of bacteriology had grown to any importance the ripening of cheese was studied from this point of view, and it was very generally concluded that the process was almost entirely due to bacteriological changes. It was believed that these changes could not take place in a temperature below that at which the germs developed to the best advantage. This would require from 60° to 80° F., and it was naturally supposed that anything within these limits was proper and necessary.

REVIEW OF PREVIOUS EXPERIMENTS IN COLD AND COOL CURING.

The first work to determine the influence of lower temperatures on the ripening of cheese was undertaken by the Wisconsin Experiment Station in 1895.[a] In this experiment cheese was cured at three temperatures, 50°, 60° to 65°, and 85° F. It was found that the cheese cured at 50° F., though requiring a much longer time than the cheese cured at the higher temperatures, broke down fully as well. It was considered by the judges to have about the same quality and value as the cheese cured at the temperature of from 60° to 65° F. It was found in this experiment that the cheese cured at 85° F. was very strong and almost unfit for use.

This proof that cheese could be cured satisfactorily below 60° F. had in it the germ of a revolution in ideas and practices concerning the process. Two important facts were brought out; the first, that cheese could be cured at a temperature much below that at which bacteria, supposed to have so much influence on the curing, could very well develop; the other, in connection with the bacteriological study which was conducted at the same time with the cheese under experiment, that the bacteria persisted in large numbers much longer in the cheese kept at a low temperature than in that kept at a higher temperature.

These experiments were soon followed by similar work in Iowa,[b] in Canada,[c] and by the New York State Experiment Station at Geneva.[d] These experiments, which were along parallel lines and gave similar results, will be mentioned again.

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[a] Annual Report, Wisconsin Experiment Station, 1897.

[b] Bulletin No. 57, Iowa Experiment Station.

[c] Annual Report, Ontario Agricultural College and Experimental Farm, 1900.

[d] Bulletin No. 184, New York Experiment Station.

THE SUBEARTH DUCT.

The conclusion, drawn from the work of these experiment stations, that low temperatures for curing could be profitably employed led to attempts to secure a lower range of temperature in the rooms already in use. An effort was made to provide better insulated curing rooms in which the temperature would not be greatly affected by hot weather outside. In a few instances in Wisconsin and in many instances in Canada some attempt was made to secure lower temperatures by artificial means. The best known of these devices is what is called the subearth duct, which is worthy of notice in any discussion of the subject of temperatures in connection with cheese ripening. The principle of the subearth duct, as is well understood by cheese men acquainted with the subject, was based upon the fact that the temperature of the earth several feet below the surface remains practically stationary and is much below the average temperature of the atmosphere during the summer months. Several lines of tiles, such as are used for drainage purposes, were laid at varying depths beneath the earth's surface and provided with a funnel which turned toward the wind at the opening where the pipe came to the surface. There was also a funnel which acted as a draft above the curing room and served to draw the air through these tiles and into the curing room. The room itself, of course, was well insulated, and it was found that by this means a fairly even temperature could be maintained at about 60° F. There were certain modifications of this duct, in some instances the curing-room air being drawn from near the bottom of a well in much the same manner. This was also a success in regulating the temperature.

In this country this method of maintaining a suitable and even temperature was for various reasons never very extensively applied, there being a difference of opinion regarding its efficiency. A number of cheese makers who had cool-curing rooms believed that they could make a softer cheese than had been customary in hot weather, but when this cheese passed from the hands of the maker to the dealer and was brought in contact with higher temperatures it caused unfavorable comment. This was wrongly and unreasonably charged to the subearth-duct curing room, when in fact it was the fault of the maker. There was also said to be considerably more trouble with mold than had been the case with the old-style curing rooms.

Had there been any necessity for the continuation of this method for securing low temperatures there is little doubt that the subearth duct or some other artificial means of obtaining the same results would have come into general use in the better cheese districts, for at the present time the bad effects of any high degree of temperature in the curing of cheese are thoroughly understood. But other methods and systems of handling cheese were developed, founded on new discover-

ies, and the development of the cold-storage system did away with any necessity for a cool factory curing room.

Following the introduction of cold-storage curing, cheese was held in the factory for a much shorter period than formerly. The subearth duct was expensive, and well-insulated curing rooms were found to be satisfactory for the shorter period before going to the storage room.

THE WISCONSIN WORK IN COLD CURING.

The work in Wisconsin, already mentioned, led Doctors Babcock and Russell to believe that the processes through which cheese passed in curing were due partially at least to other agencies than bacteria. Investigations were conducted which led to the discovery of galactase,[a] an enzyme natural to milk and which has the power of breaking down the casein. It is not the purpose of this bulletin to enter into any details of that discovery or of the controversy that has resulted between scientists on this general subject of cheese curing. This discovery indicated that it might be entirely possible to cure cheese at a much lower temperature than had previously been used, and naturally led to experiments along this line. There is no doubt that this discovery has been responsible for many changes in the cheese industry, for it has affected the curing processes, has indirectly modified the taste of the consumer, and a long series of changes has followed, some of which are still in progress.

The Wisconsin Station was the first to inaugurate experiments in the cold curing of cheese.[b] This very naturally followed the discovery of galactase and the previous experiments in cool curing, which might be considered as preliminary to the greater work that followed. Wisconsin's first work along these lines was followed in a short time by similar experiments at Guelph, Ontario, Canada, under the direction of Professor Dean, head of the dairy department of the Agricultural College. About an equal amount of work has been done by these two institutions, but of course that done by Wisconsin will always be of the greater interest, because to this station belongs the credit of having made the discovery which naturally led up to this work, and because of its general activity along these lines.

THE FIRST COLD-CURING EXPERIMENTS.

The first actual cold-curing experiments were undertaken at the Wisconsin Station following the discovery of galactase.[c] In these tests five temperatures were employed, 15°, 33°, 40°, 50°, and 60° F.

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[a] Annual Report, Wisconsin Experiment Station, 1897.

[b] "Cold curing" is the term ordinarily applied to curing at temperatures below 50° F., to differentiate it from the method employed in Canada, where artificial temperatures above 50° F. are used and the process is termed "cool curing." These terms are well understood by cheese men and are entirely distinct.

[c] Annual Report, Wisconsin Experiment Station, 1901.

Three different lots of cheese were stored at these temperatures, the lots being made up, respectively, with 3, 6, and 9 ounces of rennet to 1,000 pounds of milk. Chemical analyses made periodically after the cheese was put into storage showed by the soluble proteids that the cheese broke down more slowly in the lower temperatures. There was, however, a steady, though slow, change even at the lowest temperature of 15° F. The increased amount of rennet, according to the analyses, showed marked influence in hastening the breaking down of the curd.

In storing these cheeses at the different temperatures it was found that 40° and 50° F. gave the best results when considered by the market standards of that time. The temperature of 60° F. gave a cheese with impaired flavor and injured texture. In these tests the high-rennet cheese had the best texture, the flavor being as good as with the lower rennet. A peculiarity often noticed in cheese held at a low temperature was first seen in these experiments—that is, the development of white specks throughout the body of the cheese, which might be considered as injuring its commercial value to a very slight extent. The cheeses in these experiments were cut and photographs were made which showed the close texture of the cold-cured cheese. At the temperature of 15° F. a soggy, crumbly texture was found.[a] In this report the first suggestions were made as to the advisability of building centralized curing rooms, and the report also mentioned further experiments which were then in progress along the same line. Only partial results were given, the full statement of the completed experiment being left for a future publication.

In the publication covering the completed experiment[b] data are given as to the effect of a long period of time on the cheese carried at 33° and 40° F. This cheese was found to be of fine quality at the end of two years, while that held at 50° F. was on the decline at the end of sixteen months.

LATER WORK.

The details of three additional series of experiments are given in the same report. In the first of these the cheese was made at the university, the normal amount of rennet being added and the cheese being stored at 15°, 40°, and 60° F. The cheese held at 60° F. commenced to deteriorate in quality at about six months, and was putrid at about fourteen months. The cheese placed in the 15-degree temperature was removed to a 40-degree room at the end of seven months. In this series the cheese held at 60° F. received the highest total score, which was given when it was five months of age. The cheese kept at 40° F. received a maximum score of 1 point less than the 60-degree cheese,

[a] Further experiments modified this conclusion.

[b] Annual Report, Wisconsin Experiment Station, 1902.

reaching this at fourteen months. The cheese held at 15° F. scored very low until placed in the 40-degree room, when it commenced to improve and developed into a very fine product.

The second experiment of the series was made in a regular cheese factory, and the report states that the results are entitled to more weight than those of previous trials, as all the cheese came from the same vat. The cheese was made with 3 ounces of rennet, and was stored at 15°, 40°, 50°, and 60° F. Before being stored the cheese was divided into three lots. The first lot went into storage direct from the press, the second lot was held at 40° F. for fifteen days and then stored the same as the first lot, and the third lot was kept at 40° F. for thirty days and then stored as the others. The temperatures of 50° F. and below seemed to give the best results, the cheese cured at 50° F. being the best of all. Part of the cheese held for fifteen and thirty days at 40° F. and then for five months at 15° F. was then removed to the 40-degree room. At the end of one year some of this cheese had an almost perfect score.

The cheese for the third and last series was made in a commercial factory and was stored at 32°, 35°, 40°, and 60° F. The results were the same as in the previous trials. A number of duplicates which were put into storage were afterwards sold in the Chicago market and brought prices considerably above that obtained for ordinary cheese.

These three experiments strongly emphasized the fact that in body and texture all the cheese kept at the lower temperatures was superior, but according to the market standards of that time it would appear that the cheese cured at 60° F. was superior to the others in flavor at some periods of its ripening and would probably have brought better prices. As this prime condition for the 60-degree cheese was at about five months of age, it is exceedingly doubtful if the improved quality at the lower temperatures was of any practical benefit.

RESULTS OF WISCONSIN EXPERIMENTS.

The work done by the Wisconsin Station was summed up in another report,[a] a number of points being emphasized which had been brought out in the work of the station and which had not been given much prominence in previous reports. Attention was called to the fact that the cheese cured in cold storage was much more uniform in quality than that cured under the old conditions. It was stated that most factories suffered considerable loss from the rejection of cheese because of its inferior quality. It was pointed out that such losses were in part due to the use of tainted milk and to variation in manufacturing details, but in large measure they might be

[a] Bulletin No. 94, Wisconsin Experiment Station.

ascribed to variation in curing conditions due to inefficient methods of control. Of these curing conditions, temperature was by far the most important. With cheese cured at lower temperatures the effect of these factors was much modified, with reference not only to the conditions which occurred in the curing, but also to the variations in conditions of manufacture. The result showed that with a lower temperature the quality of the cheese is more uniform, and the product would naturally bring a somewhat higher price and be more sought after by the buyer.

An interesting feature of the work carried on by the Wisconsin Station was the placing of cheese at a temperature below freezing, 15° or 17° F. It has always been believed by people familiar with the handling of cheese under storage conditions, and it seems to be an opinion firmly held at the present time, that a temperature low enough to freeze is detrimental, if not ruinous, to the cheese. The first report of the Wisconsin Station seemed to support this idea. Cheese came from the low temperature in a very unsatisfactory condition; but further experiments along this line gave a slightly different result, the cheese being handled differently after coming from the colder temperature. In the first experiment it was scored immediately after coming from the 15-degree room. In subsequent experiments the cheese was placed in a warmer room for a time, and, as has been previously noted, there was an immediate and constant improvement until it reached an almost perfect condition, showing that the bad effect of the freezing of the cheese was only temporary. While this fact is interesting from a scientific point of view, it is doubtful if under the present market conditions it can ever be put into practical application. It is true that the cheese kept much longer at this lower temperature, and it is also probably true that the cheese could be held indefinitely at 15° F., but it is difficult to see how this could be applied to any commercial condition where it would be of any value. In short, it is doubtful if it is ever advisable to keep cheese longer than nine or ten months. Conditions may some time arise under which this would be desirable, but it is now difficult to imagine any future conditions to warrant this temperature being applied to any cheese as it comes into storage.

CANADIAN EXPERIMENTS IN COLD AND COOL CURING.

As has been already mentioned, the Ontario Agricultural College followed very closely the lead of the Wisconsin Experiment Station in curing experiments involving the effect of different temperatures.[a] In the first experiments cheese was cured at 60°, 66°, and 69° F., and it was found that that cured at 60° F. was of higher quality, both in texture and flavor, than that cured at either of the other

[a] Annual Report, Ontario Agricultural College and Experimental Farm, 1898.

temperatures. The cheese cured at the highest temperature went off in flavor very rapidly. The tests ran through a period of two months and included a large number of lots of cheese. In a series of cooperative experiments with cheese factories the same temperatures were employed and the same results were obtained.

During the following year the previous tests were repeated.[a] Results were the same as before, the cheese cured at the lowest temperature being the best in quality. It was found in these tests that cheeses of varying sizes were affected in practically the same way by the different temperatures. Some of the cheese was carried at a high temperature obtained artificially, and was then placed in the cool rooms, but this was found to be of no advantage, though no comment was made indicating that it was of any particular disadvantage.

All of the foregoing work was again repeated the following year.[b] Practically the same conditions were met as in the previous experiments, cheese being cured at 60°, 65°, and 70° F. The same results were obtained, and, as before, cheese held at a warmer temperature for one week before going into colder rooms showed no benefit derived from this process. In all of these experiments the score for flavor had been about the same for the different temperatures, but the texture was very markedly improved at the lowest temperature.

The year following a partial report was made on the employment of a 40-degree temperature for curing.[c] While the experiment had not been completed at the time of making the report, there was evidence that the cheese carried at 40° F. would be better than the control cheese carried at 65° F.

In a bulletin published in 1902 the final results of the work last mentioned were given.[d] It was stated that the temperature of the cold room averaged 38° F. and that the average temperature of the warm, or control, room was 64° F. One cheese from each lot made was placed directly in the cold room, and three others were kept in the warm room for one, two, and three weeks, respectively, and were then placed in the cold room. A fifth cheese was ripened in the warm room. The final scoring on these lots showed that the cheese placed immediately in the cold room was the best of all, while the cheese ripened in the warm room was much the poorest of any. The cheese placed directly in the cold room also lost less in weight than the others.

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[a] Annual Report, Ontario Agricultural College and Experimental Farm, 1899.

[b] Annual Report, Ontario Agricultural College and Experimental Farm, 1900.

[c] Annual Report, Ontario Agricultural College and Experimental Farm, 1901.

[d] Bulletin No. 121, Ontario Agricultural College and Experimental Farm.

The work of 1902 was continued in 1903.[a] In this series of experiments a storage room cooled by natural ice to 40° F. was compared with a mechanically refrigerated room carried at the same temperature. Cheese was also carried at 50° F. All cheese, except as otherwise stated, was placed in storage direct from the hoops. Nine lots of cheese were made and some of each stored in each room. For comparison a cheese from each lot was held in the warm room for one week and then placed in the 40-degree ice-refrigerated room, and one cheese from each lot was completely cured in the warm room, which averaged above 60° F. Nine other lots of cheese were made and stored in the same way, except that the cheese carried in the ordinary temperature for one week was placed in the mechanically refrigerated room instead of the room cooled by natural ice. In all of these tests the cheese placed immediately in the 40-degree room was slightly better at the end of the test than any other, while the cheese ripened at the ordinary curing-room temperature was of noticeably poorer quality in both flavor and texture. The cheese held in the warm room for a week was practically as good as that going immediately into storage. There was found to be very little difference in the effects of mechanical and ice refrigeration on the quality of the cheese, the small difference being in favor of the artificially refrigerated rooms. There was less shrinkage in the ice-cooled rooms, because of the higher humidity, which probably amounted almost to saturation. None of the cheese was paraffined. In connection with these experiments it was stated that cheese could be held for a week before going into cold-storage rooms without damage, provided the temperature did not go above 90° F.

The Ontario experiments were continued in 1904.[b] Several new features were introduced in this series of tests. Professor Dean tried the effect of varying quantities of rennet and also compared boxed cheese with cheese placed on the shelf and handled in the old way—that is, turned and rubbed occasionally. He also again compared ice and mechanical refrigeration in these tests. Fourteen lots of cheese were made up, seven lots with 3¼ ounces of rennet to 1,000 pounds of milk and seven with 6¾ ounces of rennet to 1,000 pounds of milk. These were carried at a temperature of 40° F., being divided between the ice-chilled and the mechanically refrigerated rooms. The score of the cheese showed no practical difference in the quality when made from varying quantities of rennet.

For the boxing and shelf test nine lots of cheese were made and were divided between the ice and mechanical storage rooms. Half of the cheese was kept on the shelf, and half was kept in boxes without turning. The results showed a slightly greater shrinkage on the shelf

[a] Annual Report, Ontario Agricultural College and Experimental Farm, 1903.
[b] Annual Report, Ontario Agricultural College and Experimental Farm, 1904.

and a slightly greater tendency to mold in the boxes. There was no difference in the quality in either case.

Six lots of cheese were made up for temperature experiments. Cheese was carried at 28°, 40°, 50°, and 55° F. The cheese ripened at 40° F. scored slightly higher, but the difference was very unimportant and was well within the limits of probable error of the judges.

For the ice and mechanical storage test thirteen days' make of cheese was used. One cheese from each day's make was held at a warm temperature for one week and then placed in mechanical storage at a temperature of 40° F., and the same plan was followed with regard to the ice storage. Three other cheeses went direct into storage from the hoops, one in the ice storage at 40° F., another in the mechanical storage at the same temperature, and the third in a 50-degree room. When these cheeses were scored, they showed very little difference in quality, as in the previous year's test, the cheese cured at 50-degree being slightly better, and the mechanical and ice refrigeration showing no difference in effects, except in the less shrinkage in the ice-cooled rooms, which was due to the higher humidity.

COMMENTS ON THE WISCONSIN AND THE CANADIAN WORK.

As has been heretofore mentioned, the Wisconsin Station deserves credit for having made the preliminary discoveries which indicated a possible adoption of lower curing temperatures, and it is entitled to further credit for having inaugurated experiments along this line. It is probably true that no two men on the continent were better qualified to have undertaken this pioneer work than Doctors Babcock and Russell. The first experiments were conducted at the station proper, and as a result of this work certain recommendations were made which have not as yet been fully adopted, but which will probably prove to be the basis for the treatment and handling of all cheese in the not-far-distant future. One recommendation was that the cheese be put into cold storage direct from the hoop, and it was pointed out that this would check the development of many undesirable ferments which appear within a few days or weeks after the cheese is made.

This purely experimental work was supplemented by additional tests in a regular cheese factory. This latter work approached very closely actual commercial conditions, and, as stated in the reports of the station, perhaps deserves greater weight than the previous work. In fact, there was an element of weakness in the first work done, because the cheese was made up in small vats, not all of the cheese in one test coming from the same vat, thus leaving a decided possibility for variation in quality.

A number of benefits to be derived from the low temperature were pointed out. It was shown that cheese made from day to day and cured under these conditions showed greater uniformity in quality,

this of course being due to the fact that undesirable qualities had very little opportunity to develop under these conditions. It was also shown that the cheese lost much less in weight when cured at the low temperature. This was a very important point at the time of these experiments. Another point was the longer period for curing and the consequently longer time during which the cheese was fit for consumption. It would appear that this was an important point, but in view of market conditions it is doubtful if this fact of longer keeping is of as great advantage as was at first supposed, except in the carrying of cheese for the winter and spring trade. It is deemed necessary by cheese makers that all cheese of a previous year's make be cleaned up by about April 1 to avoid a financial loss due to the lower prices of the new cheese, which comes on the market about this time and which appears to be just as desirable to the consumer. A few months added to the keeping period may be desirable, but one or two years would not be considered by many dealers.

In the work done at Guelph, Canada, there were two very commendable features, one being the great number of different days' make which was compared. In the experiments for 1904 alone 42 lots of cheese were made up. The other feature was the fact that all of the cheese in a single test came from the same vat of milk. As the milk at Guelph is obtained from herds scattered throughout a small territory—the same condition that prevails in the case of a commercial factory—these experiments should have great weight. It would appear that the only possible opportunity for variation or ground for criticism would be on account of the cheese not being carried in regular cold-storage establishments, such as are found in the larger cities and which are conducted upon a commercial scale.

COMPARISON OF ICE AND MECHANICAL REFRIGERATION.

An interesting feature of the Ontario work was a comparison of the effect upon cheese of ice and mechanical refrigeration. This was a point well worth investigating, especially in the days before paraffining had become general. It is difficult, however, to comprehend how the cheese could be influenced to any appreciable extent by the fact that one room was cooled by ice and another by some other means. The only probable variation in the condition of the atmosphere would be in the relatively higher humidity in the rooms cooled by ice. At the present time, when practically all the cheese that comes into cold storage is paraffined, any variation in the moisture content of the air would have no effect whatever, or certainly none that need be taken into consideration. The cheese used in the Canadian experiments, as well as that used in the Wisconsin work, was not paraffined, and it was thought probable that the humidity would lessen the shrinkage and through this influence the quality. As was brought out in the

experiments, the cheese kept in the ice-cooled rooms did lose a little less in weight, but the quality was the same, as nearly as could be determined by the judges. A little more trouble with mold was experienced in the ice-cooled room, due to the humidity of the atmosphere. Since the adoption of paraffining, it is probable that a high humidity would be undesirable because of the possible effect it might have on the paraffin. This is merely assumed and has no experimental foundation, but it is entirely possible that the effect would be unfavorable.

INCREASE OF COLD-STORAGE PLANTS IN CHEESE DISTRICTS.

The practical application of results obtained by the Wisconsin Station was indicated in the recommendation made by Doctors Babcock and Russell that central curing rooms be built. These rooms were designed to take the place of the ordinary factory curing rooms and were to be situated close enough to a number of factories so that the cheese could be taken from such factories to the curing room every few days. These rooms were to be looked after by competent men and were to be kept at temperatures under 50° F. One such curing room was actually built at La Crosse, Wis., and was in operation for a short while, but through some mismanagement or poor planning was forced to cease operations. The further building of such curing rooms was probably stopped by the great number of cold-storage warehouses, which were soon built in the towns near the cheese districts. In New York such establishments are found at Watertown, Lowville, and Jamestown; in Wisconsin they are found at Sheboygan, Fond du Lac, Plymouth, and many other places situated in or near sections of the State devoted largely to the cheese industry. These storage places did away with the necessity for the centralized curing room, though in fact they are an adaptation of the idea on a slightly different business basis from that which was at first contemplated. The dealers who buy cheese direct from the factories are located near these storage houses, and at Plymouth, Wis., half a dozen of the largest cheese firms in the world have their main offices, though the town itself is only a small country village. This is perhaps the most marked example of the present condition.

With the building of these storage houses near the cheese factories it naturally followed that cheese commenced to find its way from the factories into the hands of the dealers much sooner after leaving the hoop. This tendency has increased until now the cheese is under two weeks of age, as a rule, when placed in storage; in fact, it is as young as the dealers will accept it at the present time, for reasons which will be mentioned hereafter. This is the logical outcome of the whole question of the cold curing of cheese. There will undoubtedly be changes in details, but the main points will probably not be changed under the present conditions. Curing in the cheese factory is a thing of the

past in sections closely connected by rail with towns having cold-storage houses. The tendency is for the dealer to take the cheese closer to the hoop, and anything that will show how this can safely be done will hasten the adoption of the recommendation and idea advanced by Doctors Babcock and Russell—namely, that cheese should go into storage the day it is taken from the press.

COMPARATIVE ADVANTAGES OF COLD AND COOL CURING.

The outcome of the experiments in Canada has been a little different from that of the Wisconsin experiments. In fact there are many things regarding the situation as it is found in Canada which are very difficult to explain. The work done at Guelph would seem to have indicated that cold storage was the only correct way of handling cheese. Canada has a department of agriculture, with a dairy commissioner who has always been actively interested and taken a leading part in the development of the cheese industry of the Dominion. On the basis of results obtained in tests that were carried on in various factories, cooperative cool-curing rooms were recommended. As has been heretofore explained, these rooms were to carry a temperature above 50° F.; in fact, in practice they averaged about 58° F., according to the reports. These rooms were necessarily cooled by artificial means during a part of the year. In advocating this cool-curing system in preference to cold curing, three arguments were advanced. One was that the expense of holding the rooms at the higher temperature is much less than would be required for a temperature of 40° F.; another was that the time required for curing is only about one week longer in the cool rooms than would be necessary in the ordinary factory curing rooms; while the third argument was that in the cool rooms cheese developed a decided flavor which was necessary for the export trade.

On the recommendation of the Canadian department at least three such rooms have been built in as many different sections. They appear to have given perfect satisfaction, and cheese cured in these rooms was of course of a much more uniform quality and the shrinkage much less than with the old conditions of factory curing rooms. The general scheme was to pay for storage about what was saved in the shrinkage. This saving did not quite pay for the actual cost of maintaining the rooms, but it is probable that if the better quality of the cheese due to being cured under such favorable conditions could be taken into consideration the benefits derived would undoubtedly pay or more than pay for the actual cost. A number of factories patronize each of these cool rooms, teams being furnished to collect the cheese practically every day by making a circuit of the factories. This plan gets the cheese into a favorable temperature almost as it comes from the press, and is undoubtedly a desirable feature.

One of the arguments in favor of the cool rooms and which has been urged in this country against the employment of cold storage for curing cheese is based on the fact that perhaps the best cheese made in the course of the season comes from the factories in the latter part of September and during October. In this connection English Cheddar cheese, to which reference is often made, is cured at about the same temperature as would prevail in the American cheese districts in October, which would be about 60° F. This argument is very unscientific to say the least. There are other probable reasons for the superiority of our September and October cheese. This season is especially good for the production of very fine milk; nights are cool and the milk easily kept, and the cows have advanced in lactation until there is a relatively high percentage of fat in the milk. The English Cheddar, the superior qualities of which are probably much due to imagination, is made under almost the same conditions of climate as prevail in this country in the early autumn. The English summers are very cool, giving a fine opportunity for producing good milk; and the quality of the English cheese, if as good as claimed, is undoubtedly due to this fact rather than to any superiority of curing temperature over the regular cold storage.

It is doubtful if the argument advanced concerning the comparative cost of "cool-curing" rooms and "cold-curing" rooms has any material foundation. In theory it would, of course, cost more to hold a room at 40° F. than at 55° F., but considering the amount of cheese that even a small cold-storage house will hold and the relatively small cost per pound for this storing, it is doubtful if the comparative cost would have any great influence. It seems that no figures have been compiled to show what has been the actual cost of storage in the cool rooms per pound of cheese. The Dairy Division of this Department requested such information from the Dominion government, but was told that it was not available. However, prices charged for the storage of cheese in various cold-storage houses in this country were obtained. One storage firm quotes one-fourth of a cent per pound for five months from June 1 and one-half a cent per pound for nine months from June 1. A large Chicago house charges 16 cents per 100 pounds for the first sixty days or any part thereof and 8 cents per 100 pounds for each succeeding thirty days. This amounts to about one-twentieth to one-eighth of a cent per pound per month. This would appear to be such a reasonable charge that it would be difficult for any other system to show any appreciable advantage.

The contention that the comparative difference in the time of curing is considerable does not appear to have any real foundation. In general terms it was claimed that the cheese in the cool-curing rooms required but about one week longer for curing than would be necessary under factory conditions, while it was further claimed that cheese

carried at 40° F. required about four times as long a period for ripening. The latter part of this contention is probably true, as it was shown by the Wisconsin Station through chemical analyses made during the course of ripening that cheese held at 40° F. broke down in four weeks to about the same extent to which cheese carried at 70° F. would break down in one week, and according to the reports of the same station there was a decided difference in the rate of curing of cheese held at 55° and at 65° F.—much more, in fact, than was claimed in the arguments for the cool-curing rooms.

In connection with the claim that the cheese cured in the cool-curing rooms had a more desirable flavor than cheese cured in the cold-curing rooms, there seems to be room for a decided difference of opinion. As has been previously mentioned, the market demand is growing rapidly toward a cheese of mild flavor. This will be mentioned hereafter, but in this connection it may be stated that the scoring of the cheese in the experiments conducted at Guelph was done by well-known Canadian buyers and exporters, and in their opinion the cheese cured at 40° F. was slightly superior in quality to that cured at 60° F.

The Canadian cool-curing rooms attempt to pay expenses by the saving in shrinkage. In cold curing, as now generally practiced in this country, cheese is paraffined as it goes into storage, thus preventing practically all shrinkage. Otherwise the shrinkage would amount to about 1 pound or more in 20, and at 10 cents a pound this saving in shrinkage would be sufficient to carry the cheese in storage for nine months at the prevailing rates.

Evidently one fact that has not been taken into consideration is that a temperature of 55° or 60° F. will not check many undesirable ferments which may occur in the ripening cheese. It was emphasized by Babcock and Russell that one of the advantages in a cold-curing room lay in the fact that many undesirable qualities due to conditions which existed at the time of making could be almost entirely overcome by the use of very cold temperatures in curing. This would not hold true for the cool-curing rooms. It would be impossible, owing to these factory conditions, to get such an even quality of cheese in the cool rooms as could be secured by the use of the lower temperatures.

COOPERATIVE WORK BY THE DEPARTMENT OF AGRICULTURE AND STATE STATIONS.

At the suggestion of the Wisconsin Experiment Station the Department of Agriculture, through the Dairy Division of the Bureau of Animal Industry, in 1902 entered into a cooperative arrangement for conducting some commercial experiments on the cold curing of cheese.[a] The station at first contemplated that all the work should be

[a] Bulletin No. 49, Bureau of Animal Industry.

undertaken in that State and the cheese made in factories over which the station could exercise a certain degree of control. Upon the suggestion of the Dairy Division, however, the work was broadened so as to include the New York State Station at Geneva, and was further extended to include cheese from a number of different States, namely, Pennsylvania, Ohio, Michigan, Illinois, and Iowa. Storage facilities for the Eastern States were secured in New York City and for the Western States at Waterloo, Wis.

Different types and styles of American cheese were gathered from the factories scattered throughout the States mentioned. This cheese was stored, without paraffining, at 40°, 50°, and 60° F. Three judges scored the cheese in charge of the Wisconsin Station, and a different set of three judges scored the cheese in charge of the New York Station. Mr. Baer, expert cheese maker for the Wisconsin Station and university, made periodical inspections of the Waterloo cheese in addition to the regular scoring by the judges. The Wisconsin cheese was scored at the end of three months and again at the end of five months. The score showed a slight difference in favor of the cheese kept at 40° F. This difference was greater at the end of five months than at the end of three months, though at neither time did the average variation reach a total of 4 points out of a possible 100. The market value was placed on the cheese by the judges and showed slightly in favor of the cheese stored at 40° F.

The cheese in charge of the New York Station was scored at five different times—when fresh, at the end of two months, at the end of four months, at the end of six months, and again in eight months. The cheese held at 60° F. was sold at the end of four months, as it had commenced to deteriorate. The lowest score was given to the cheese held at 50° F. at the end of six months. The cheese held at 40° F. gave a slightly higher maximum scoring, and, as had been demonstrated in previous experiments, remained in good condition very much longer.

In addition to this regular work, one of the New York City cheese dealers furnished a quantity of cheese to be used in paraffining tests. Half of this was paraffined and half remained unparaffined. Both lots were divided between the 40°, 50°, and 60° rooms. The results showed a decided saving in shrinkage in the paraffined cheese and no effect on quality.

There are several things connected with the scoring in New York City which are a little difficult to understand. The cheese when green scored practically as high as when thoroughly ripened. No explanation was offered, and evidently none was called for on this point, but it is difficult to understand why such a high score should have been given at that time. It is impossible for cheese fresh from the press to have the characteristics of a desirable texture. It has no developed flavor

and its qualities at best must have been purely negative. Another point in connection with the scoring was the fact that such small differences in quality were noted between the different lots of cheese. The cheese was selected from a number of different factories, was subject to adverse influences before arriving in New York, and it is improbable that it could have been so nearly of the same quality. The explanation of this point, if there be any explanation, is probably that all three judges were commercial men, that all of the cheese, according to commercial standards, was well above the quality demanded for the highest prices, and consequently the judges did not discriminate to any extent within these limits. From a commercial standpoint the scoring and its results were undoubtedly entirely satisfactory, but from an experimental point of view it would appear that there was something more to be desired.

Another point in connection with this cooperative work as affecting both New York and Wisconsin and which might be considered subject to some criticism was the fact that the cheese for these experiments was obtained in quantities varying from 500 to 1,000 pounds from each factory. It is extremely improbable that in the case of the larger amounts coming from a single factory the cheese was all made in one vat. It would seem that a thoroughly satisfactory test would have required that the cheese from each and every factory should be divided between the different temperatures selected for storing on the basis of the vat in which the cheese was made—that is, that each vat of milk should have been considered by itself in dividing the cheese for the different temperatures of storing. Two vats of milk on the same day can easily vary as much in quality as the milk of widely separated days. It is a well-known fact that where more than one vat is run in a factory on the same day cheese of the very highest quality may be made in one vat and of exceptionally poor quality in another. In these experiments, in a number of cases at least, it appears as though the cheese from each factory was lumped together without reference to whether it was made in one or two vats, and it is quite likely that some variation in results was due to this fact, as such could easily have been the case had the cheese varied as much in quality as it frequently does under such conditions.

This cooperative work was impaired somewhat, in the writer's opinion, by the insistence of the Department of Agriculture that the cheese should be gathered from so many different sources. It was, of course, impossible to supervise or control the making of the cheese under such conditions. Then, too, such long shipments were required in many instances that the cheese was several days old before going into storage. There is no question but the work would have been much more valuable could it have been done in one locality where some direct observations could have been made on the manu-

facture. Care was used in selecting the factories from which the cheese was to come, but this did not overcome the weak points in the general plan.

MINOR EXPERIMENTS BY THE IOWA AND NEW YORK STATIONS.

In addition to the more extensive experiments conducted in Wisconsin and Canada and the cooperative work in which the United States Department of Agriculture took part, some minor work on the effect of temperature in cheese curing has been done at the Iowa Station[a] and at the New York State Station.[b] These experiments were concluded before the regular cold-storage work was undertaken in Wisconsin and Canada.

The work in Iowa was partially in cooperation with Canada. Cheese was shipped from Ontario and cured at a temperature of about 60° F. Other cheese was cured at 55° F. In another test, fresh cheese was held at 90° F. for a few days after making and then cured at a lower temperature. It was concluded from these experiments that the exposure to a high artificial temperature for several days before going into the colder rooms had no bad effect.

In the New York State Station test temperatures of 55°, 60°, 65°, 70°, 75°, and 80° F. were employed. The cheese cured at 55° F. scored 7 points higher than that cured at 65° F. and above.

Besides the conclusion announced as a result of the Iowa experiments in cool curing, to the effect that cheese could be held at a relatively high temperature several days before going into the colder rooms without injury, this same statement was made as a result of some of the Canadian experiments, and was repeated by the Wisconsin workers in connection with their recommendation for a central curing plant. Mention has previously been made of the recommendation of the Wisconsin Station that cheese should go into storage direct from the hoop, and it would appear that these statements were rather inconsistent. There is no doubt that all these investigators were in error in their statements, as a general proposition, that cheese could be held at a high temperature even for a few days without injury. It might be true of cheese which had been made from pure milk, under exceptionally good conditions; but where undesirable flavors have a tendency to develop, any period of high temperature, no matter how short, after leaving the press would undoubtedly give undesirable results. The fact that in many cases the cheese which went direct into storage was given a higher score than that which remained in the ordinary curing rooms for from one to two weeks is proof of this statement. Although some cheese can stand

[a] Bulletin No. 57, Iowa Experiment Station.
[b] Bulletin No. 184, New York State Station.

a warm temperature without injury and could even be cured at a temperature of 70° F. and come out with an almost perfect score, as has been shown on many occasions, this is no proof that the warm temperature is desirable for curing.

REPORT OF RECENT EXPERIMENTS BY THE DEPARTMENT OF AGRICULTURE.

The Dairy Division thought it wise to conduct further experiments in cold curing, as the only commercial test made in which the Department cooperated was so unsatisfactory that it did not lessen the desirability for further work of this nature. Again, market conditions had changed so radically that the work performed and the conclusions drawn therefrom, which might have been entirely satisfactory a few years ago, would not apply to present conditions.

A number of questions have been advanced by dealers who utilize cold storage in regard to recommendations made on the basis of previous experiments to the effect that cheese should go into storage direct from the hoop. The dealers have been afraid to adopt this view entirely, though the general method of handling is perhaps growing slowly in this direction. Perhaps the reason advanced by most dealers against buying perfectly fresh cheese is that it is impossible to tell, when a cheese is inspected too young, just how it will develop. Any bad qualities, or at least a few of the bad qualities, which are likely to show in the cured product can not be detected in a cheese a day old. The most important of these possibly injurious qualities is in connection with the development of acid, though undesirable flavors would perhaps be mentioned by many of the dealers. It is well known that a high-acid cheese appears perfectly normal as it comes from the press, and the fact that there is too much acid does not show until the cheese is at least a week old or even two weeks old. In certain seasons of the year this is a fault that is very likely to occur at times in all factories, and as a high-acid cheese brings a much lower market price the dealers have a just reason for being suspicious of fresh cheese. The contention that other faults may develop will not be so difficult to overcome. It has already been proven that cold storage checks a great majority of the undesirable ferments, and a fault which is not noticeable in the green cheese will not be likely to develop after the cheese is placed in storage at a temperature too low for bacteriological changes. This needs to be demonstrated perhaps a little further and to be impressed upon the minds of the dealers. The work heretofore conducted has been almost without exception with a very high-grade product. In previous tests the cheese ripened at the ordinary curing-room temperatures rated above the requirements for the highest market price, and because of this the experiments did not demonstrate the great advantages of the early application of cold temperatures.

TRADE CONDITIONS AND PRACTICES.

Before undertaking the work covered by this report a very careful investigation of conditions affecting the cheese industry was made. This investigation showed that the practice of putting cheese into cold storage before it was cured had become almost universal. Very few factories throughout the cheese districts of New York and Wisconsin keep the cheese on hand for a longer period than two weeks. This means that the ripening process has progressed very little before the cheese goes into storage, and the greater part of the curing, if it takes place at all, must be done at the low temperature.

There was, however, within narrow limits, considerable variation in the age at which the cheese was placed in storage. Some dealers were willing to take it when one week old, while others insisted that it be two weeks old. The time varied somewhat, however, with the market demands and the season of the year. It was an open secret that at certain periods when cheese was scarce and the demand insistent cheese would be taken when four days old or even less, though this was not put into storage, but as a rule was shipped immediately to the consumer.

The temperatures employed at the different storage houses showed considerable variation. It appeared that at some a temperature as low as 30° F. was used, while at others the temperature employed was slightly above 40° F., a majority ranging from about 34° to 36° F. No reason could ever be obtained why any one establishment employed a particular temperature, the managers of those using the lower temperatures simply stating that the temperature was as low as possible without danger of freezing the cheese.

PLAN OF THE WORK.

In planning for the work in view, the points brought out in previous investigations served as a basis for the experiment. As the custom of curing cheese in the factory curing room had practically ceased to exist, there was no reason for making any particular effort to demonstrate the superiority of cold curing over the old method. It seemed to have been sufficiently demonstrated both in this country and in Canada that a temperature of 50° F. or lower was the most satisfactory for cheese ripening, so no particular weight was placed on any further demonstration of this point, though a few cheeses were carried in the factory curing room to show what a long exposure to high temperatures might develop in a cheese which would otherwise have been of a high quality.

As the temperatures employed by different storage houses varied from about 30° to 40° F., two temperatures were selected for our work—namely, 32° and 40° F., and as cheese is placed in storage at

various ages, in these experiments cheese fresh from the press and at one and two weeks of age was stored in rooms of different temperatures.

There has been considerable discussion as to the effect on ripening of different styles, shapes, and sizes of cheese. It seems to have been demonstrated in Canada on one or two occasions, and also in the cooperative experiments hereinbefore mentioned in which the Dairy Division took part, that the size of the cheese had very little influence on its quality. There is a popular belief, however, that the large Cheddar cheese weighing from 60 to 100 pounds develops a better texture and perhaps a better flavor than smaller types. This is extremely doubtful when considered in the light of actual knowledge. The size of the cheese was given no consideration, as it was believed that it would have no important bearing upon this general problem. If cold storage benefits a small cheese, it should certainly benefit a large one, and vice versa. The only exception that could possibly be made to this statement would be in connection with the possible variation in water content of the small and large types. The small cheeses are as a rule not subjected to so great pressure as are the large ones, but even if this were not the case it is doubtful if the amount of pressure applied plays any important part in the water content of the cheese. Analyses go to show that small types of cheese possess about the same percentage of water as large types. For the experiments the "Daisy" style of cheese was chosen. It is about halfway between the extremes of size represented by the old-fashioned "Cheddar" and the "Young America." It is, moreover, an extremely popular size, often bringing in the regular market as high as a cent a pound more than the other styles. It is shaped about like the old styles of cheese, and is of sufficient size to permit heavy pressure.

In selecting a place for the experiments the ground was gone over carefully and a number of things were taken into consideration. Previous work has usually been carried out with the factory and place of storage so widely separated that accurate work was impossible. It was impossible for the man in charge of the work to look after the details of the storage, and the distance did not permit of cheese being taken direct from the hoop and put into storage the same day.

In the first place it was desired that this work should be put on a commercial basis as far as possible and that the cheese should be made in a commercial factory representative of a large number of factories. To do this required that the work of both making and storing should be done in some rural district. But two suitable locations could be found—Utica, N. Y., and Plymouth, Wis. The storage plants at these points employed mechanical refrigeration, which permitted variation in temperature. A number of storage establishments in both Wisconsin and New York used natural ice and were not arranged to allow any great variation in the temperature of different rooms or

to secure constant temperature in the same rooms. The Plymouth storage warehouse is situated in the heart of a region devoted almost exclusively to the cheese industry. Perhaps 25 factories of large size are to be found within a radius of 5 miles. This was considered the best location, and very satisfactory arrangements were made with the proprietors of the storage establishment located at that place. The factory selected was only 3 miles from the storage house, was the largest factory in the district, receiving 15,000 pounds of milk per day, and was owned and operated by an unusually successful cheese maker. The milk received at this factory was of about the same quality and sanitary condition as would be found in a majority of the factories in the district. The factory itself was not a model, as that term would ordinarily be understood, but it was a good, practical establishment, with good equipment and satisfactory sanitary surroundings. The maker was a man familiar with the cheese business in nearly every phase, and was able to give most excellent advice and assistance.

The Wisconsin Dairymen's Association was very naturally interested in the work that was being conducted within the State, and when requested gave the services of its traveling cheese instructor on two occasions to serve as a check on the work being done. This was thought desirable in order to make the cheese representative of the whole State rather than of one locality or factory.

In these experiments it was planned to make cheese four days each week, low-rennet cheese being made one week and high-rennet cheese the next, and then a week intervening in which no cheese was made and the work in the storage rooms looked after. This plan was followed except on two occasions, when the cheese was made only three days in the week. Fifteen lots of low-rennet cheese and eleven lots of high-rennet cheese were made up, being in all twenty-six days' make.

The first lot of cheese was made June 19 and the last lot in the regular line of experiments August 24. It would have been more desirable to have commenced this work about the 1st of June, but, unfortunately, arrangements could not be completed by that time. However, the experiments covered the greater part of the storage season, and were therefore of sufficient duration to be representative of the cheese which is held in storage throughout the summer and fall.

DETAILS OF MANUFACTURE, STORAGE, AND CURING.

LOW AND HIGH RENNET.

As had been done in some of the previous work both in Wisconsin and in Canada, cheese was made up for these experiments with different quantities of rennet, the normal amount of 3 ounces to 1,000

pounds of milk being used for part of the work and double this amount for the remainder. This was thought desirable, as under the present market conditions much of the cheese is rushed from the factory to the consumer, and with our present knowledge of cheese as a food product it is desirable that at least some degree of ripening should occur before the cheese is eaten. It is entirely possible that a great deal of cheese, especially in the early spring, gets into the hands of the consumer at two weeks after making. Ordinarily there would be very little chance for breaking down or ripening to occur within this period. It has been demonstrated that rennet hastens this process, and it is quite desirable, or at least appears to be desirable, to have some means for hastening the ripening either when the cheese goes upon the market so young or when it goes into storage direct from the hoop, as the cold temperature of course checks the ripening process. Unfortunately there was no opportunity to compare the exact rate of ripening of the high and low rennet cheese. This has been done, however, in Wisconsin, and it was demonstrated thoroughly that cheese made with double the usual quantity of rennet broke down much faster than that with the ordinary quantity. The cheese in our experiments was closely observed and the rate of ripening was determined, so far as this could be done without chemical analysis.

If the use of larger quantities of rennet ever becomes customary, it will be desirable to have some data to show the effect of the rennet on the quality of the cheese as well as on its rate of ripening. This, of course, is demonstrated more or less thoroughly in the work here presented.

SELECTION AND HANDLING OF MILK AND CURD.

As has been noted before, the cheese for these experiments was made on a commercial scale. It was made up entirely in a large vat holding about 5,000 pounds of milk, and in no case were any small experimental lots manufactured. At first there was an attempt made to select milk that would make up a good cheese. This was done by watching the development of the milk in the three vats in the factory, and about the time the whey was drawn selecting the most promising curd. This was discontinued, however, after a few days, and the plan then followed was to watch the vats from day to day and take the contents of the vat that appeared to be doing the best for a continued period of time. This resulted in getting a few lots of cheese that were not the best, as shown in the curd; a number of the curds were tainted, and in one or two instances the curds were slightly gassy. This was not undesirable, however, from an experimental point of view, for any benefits that may be derived from storage are likely to be in its application to what might otherwise be a poor cheese. In fact, this is a line of work that the Dairy Division has in view for the future.

The curds for these experiments were cooked a little more firmly than was the custom in most of the cheese made in this factory. The tendency in the factories of both Wisconsin and New York is to make a cheese as soft as possible, or, what is more to the point, to incorporate all the water possible in the curd, as the reputation of the maker at the present time depends perhaps more largely upon the yield secured than on the quality, and consequently a large number of makers pay but little attention to quality and considerable attention to means for securing quantity. However, for the experiments under discussion, quality was considered first and quantity last. The cheese was probably not cooked quite as firm as was the custom among cheese makers ten or fifteen years ago, but it was carried far enough to insure a product that would stand up in the warmest weather, and which from every point of view would be considered a very satisfactory article.

All the cheese was made according to what is known as the Cheddar process. The acid was allowed to develop to a certain point before the milk was set and to develop further to a certain degree, as shown by the iron test, before the whey was drawn. After the first few weeks of the making an acidimeter was installed and used constantly in parallel tests with the hot iron. The curd was cooked and allowed to break down or mellow to about the extent required by most cheese makers. It was ground in a mill with knives for cutting rather than tearing the curd. It was then allowed to stand until it stopped draining and reached about the proper condition, and was then rinsed with warm water and salted at the rate of about 2 to 2¼ pounds of salt to 1,000 pounds of milk.

METHOD OF STORING AND CURING.

As before stated, the cheese was made up in the "Daisy" style as being perhaps the most popular form of cheese made in the Northwest. From the vat of milk selected about 14 cheeses of this style were taken every day. Of these 2 were allowed to ripen in the factory curing room, 2 were placed at once in the 32-degree room, 2 were placed at once in the 40-degree room, 2 were placed in the 32-degree room and 2 in the 40-degree room at the end of one week, and 2 were placed in the 32-degree room and 2 in the 40-degree room at the end of two weeks. They were divided in pairs in this manner so as to be sure of having duplicates to take the place of any cheese which might be injured or possibly lost. As has been mentioned, the factory was located near the storage house, and it was possible to get the green cheese into storage exactly at the times specified. Cheese taken from the hoop in the morning was put in the storage house in the afternoon.

PARAFFINING.

All of the cheese put into storage at the end of one and two weeks was paraffined, the factory being provided with an outfit for this purpose. The cheese which was immediately placed into storage was not paraffined until from 3 to 5 weeks old, as it is popularly believed among dealers that cheese direct from the press can not be paraffined without injury to quality. The cheese remaining in the factory curing room was not paraffined. Some difficulty was encountered in the paraffining work with the cheese which remained in storage for several weeks before paraffining. This period had given the mold time to commence developing, and when the cheese was paraffined in a vat belonging to one of the dealers located near the storage plant the cold surface of the cheese, by cooling the paraffin, prevented the mold spores from being killed, and the mold developed after the cheese was returned to storage. In addition the cold surface caused an unusually heavy white coating of paraffin to stick to the surface, and, the growing mold ruining the surface of the cheese, the combination gave the cheese a bad appearance. After the first few lots were paraffined in this manner the cheese was held in the hot paraffin until the surface had time to become warm. This killed the mold spores, made a much thinner coating, and altogether overcame the previous trouble.

DETAILS OF MAKING THE CHEESE.

A very careful record of all experimental data was kept from the time the milk entered the factory until the cheese went into storage. This record is presented in tabulated form, as follows:

TABLE I.—*Data of making the cheese.*

Lot.	Rennet test.	Time to cutting.	Temperature of cooking.	Time to reach cooking temperature.	Time to drawing.	Acid.	Iron test.	Time to grinding.	Acid.	Iron test.	Time to salting.	Iron est.	Degree of firmness to which cooked.	Flavor.	Remarks.
	LOW RENNET (3 OUNCES TO 1,000 POUNDS OF MILK).														
	Minutes.	*Minutes.*	*° F.*	*Hours.*	*Hours.*	*Per ct.*	*Inches.*	*Hours.*	*Per ct.*	*Inches.*	*Hours.*	*Inches.*			
1	3:00	40	99	1:40	2:20	....	1/16	4:20	....	3/4	5:20	1⅛	Medium	Clean	Close body.
2	2:45	30	100	1:30	2:15	....	1/8	4:15	....	1	6:30	1½	Firm	do	Do.
3	3:00	35	101	1:50	2:15	....	1/8	4:45	....	1¼	6:05	....	Soft	do	Do.
4	3:00	35	100	1:35	2:10	....	1/8	5:10	....	1½	6:10	1¾	Firm	do	Open body.
5	3:00	40	101	1:25	2:40	0.22	1/4	5:10	0.80	1	7:10	....	do	do	
6	3:45	40	99	1:40	3:10	.20	1/4	5:10	.70	1	6:10	....	Very firm	do	A very fine curd.
7	4:15	35	98	1:35	3:15	.20	1/4	5:35	.80	1	7:15	....	do	do	
8	4:15	35	98	1:35	3:15	.20	1/4	5:35	.80	1	7:15	....	Firm	do	Appeared wet on the rack.
9	3:20	35	99	1:20	2:50	.15	1/8	6:05	.75	1¼	7:05	....	Soft	do	Curd becoming firm on the rack.
10	3:30	35	99	1:25	2:50	.16	1/8	4:50	.75	1¼	5:50	....	do	do	Appeared whey soaked on the rack.
11	3:30	35	99	1:20	2:45	.16	1/8	5.15	.75	1¼	6:15	....	Firm	do	
12	3:50	35	99	1:20	2:55	.16	1/4	5:25	.80	1	6:55	....	do	Tainted	
13	3:40	40	98	1:20	2:15	.16	1/8	4:45	.70	1	5:45	....	Medium	Clean	A fine curd.
14	3:40	40	99	1:20	2:40	.15	1/4	5:10	.75	1¼	6:40	....	Firm	Badly tainted	Had pinholes.
15	3:15	40	99	1:10	3:25	.15	1/4	6:10	.75	1	7:10	....	do	Clean	A very slow-working curd.
16	3:00	30	99	1:00	1:45	.16	1/4	4:15	.83	1¼	5:45	....	do	Soap taint	Pinholes, fast working.
	HIGH RENNET (6 OUNCES TO 1,000 POUNDS OF MILK).														
1	3:30	30	100	1:30	2:30	0.17	1/16	5:45	0.70	1	6:45	1¼	Firm	Clean	
2	3:00	25	101	1:15	1:55	.20	1/8	4:15	.60	3/4	5:15	1	do	do	
3	3:10	20	99	1:15	2:50	.20	1/4	5:20	.70	1	6:20	1½	Very firm	do	Appeared soft and moist on rack.
5	3:20	25	100	1:25	2:35	.16	1/8	4:55	.60	1	6:25	....	Firm	do	Appeared wet on rack.
6	3:10	25	100	1:25	2:05	.18	1/4	3:35	.70	1	5:05	....	Medium	do	
7	3:45	25	100	:55	2:25	.17	1/8	5:10	.75	1¼	6:40	....	Firm	do	
8	3:30	25	99	1:15	3:10	.16	1/8	5:40	.75	1¼	7:10	....	do	do	Very dry.
9	4:00	25	100	1:00	2:55	.16	1/8	6:55	1.00	3/4	8:25	....	Very firm	Acid taint	Became very soft on rack.
10	3:40	22	98	:52	2:22	.15	1/8	4:52	.80	1¼	5:52	....	Firm	Clean	Very fine curd.
11	3:40	25	98	1:00	2:25	.16	1/8	4:55	.80	1½	5:55	....	do	do	Do.
12	3:45	25	99	1:00	2:55	.16	1/8	5:25	.75	1½	6:25	....	Very firm	do	Do.

It is understood by cheese makers that milk develops so differently from day to day, or even for the same day in different vats, that it is impossible to make an exact schedule of treatment which would apply to every lot of cheese made. Only one factor was constant, and that was the temperature of setting the milk, which was always exactly 86° F. The rennet test of the milk was always made before setting, and the milk reached about a certain degree of ripeness depending upon the way it had been developing. The regular Marshall rennet test was used, but instead of timing it by degrees as is customary it was timed by a watch in minutes and seconds, which on the whole was much more exact and satisfactory. The table shows that the variation in the rennet test was from two minutes and forty-five seconds to four minutes and fifteen seconds. This wide range was not accidental, but was due to the fact that the milk was ripening at different rates at these different periods. The time from setting to cutting varied with the low-rennet cheese from thirty to forty minutes and with the high-rennet cheese from twenty-two to thirty minutes. The cheese was cut when the stage of coagulation adopted by most cheese makers was reached. It is impossible to describe this stage intelligibly, but it is well known to practical cheese makers. The temperature of cooking varied from 98° to 101° F. The vats in which the cheese was made had mechanical agitators, which required a little higher cooking than under the old method of stirring by hand and with rakes. The time for cutting, cooking, drying, and salting is calculated from the time of setting, so that under the headings for time of grinding and time of salting six hours and fifty-five minutes or five hours and thirty minutes, as the case may be, means that that length of time had elapsed since the milk was set. The time for drawing the whey was regulated by the acid test after the first week, though as a check the iron test was made at the same time. The acid was allowed to develop about as high as was safe without causing an acid cheese. The time of grinding was regulated by the condition of the curd, and at this time also the acid and iron tests were made. Salting was likewise regulated by the condition of the curd. The other columns of the table devoted to firmness, flavor, and remarks will be taken up in discussing individual lots of cheese in connection with the scores.

TREATMENT OF FACTORY-CURED CHEESE.

The first part of the cheese kept in the factory curing room was held until it had about reached its prime condition, when it was put into the 32-degree room and held there until all the factory-cured cheese was ready for scoring. As heretofore stated, the factory curing was not considered an important feature of the experiment, though there were several points brought out in the development of flavors in this factory-cured cheese that were of great interest in connection with

future work contemplated by the Dairy Division. It was not considered of sufficient importance to warrant calling together the regular judges for this work, and so only one man inspected this cheese. Further, it was not regarded of enough importance to warrant taking up the time of this man for more than one day, on which all of the cheese was scored. This of course made the first cheese manufactured considerably older than the last, and it introduced a disturbing factor in the putting of the first cheese into the 32-degree storage room. However, as fine distinctions in the comparative quality of this lot of cheese were not desired, the information received was all that was wanted.

THE JUDGES AND THE SCORING.

Mr. U. S. Baer, assistant dairy and food commissioner for Wisconsin and formerly cheese expert for the university and experiment station, scored the factory-cured cheese. He also assisted in the scoring of the cold-storage cheese, the other two judges being Mr. C. A. White, of Fond du Lac, Wis., and Mr. I. W. Steinhoff, of Stratford, Canada. Mr. White was unanimously indorsed for this work by the cheese dealers of Plymouth and Sheboygan and was widely recommended by persons connected with the cheese industry of the State. Mr. Steinhoff is an exceptionally well-known cheese man in Canada, doing a large business and having been connected with the scoring in the experiments conducted at Guelph. These three men made a very satisfactory combination, as all had spent many years in handling cheese and each was an expert in his particular line. Mr. Steinhoff represented the Canadian idea and was an authority on export cheese, and Mr. White was perhaps as well acquainted with and as able to anticipate the popular taste for cheese in the United States as any other dealer. These two men viewed the subject largely from a commercial standpoint, while Mr. Baer, who had been connected with the experimental work of the Wisconsin Station, was well qualified to represent the educational or experimental phase.

The cheese was of course not scored as it went into storage. The notes on the condition of the curd and the way the cheese was made would be far more accurate as an indication of the condition and quality than any expert scoring of cheese fresh from the hoops could possibly be. Moreover, as all of each lot came from one vat, it was of course identical and required no inspection for the purpose of properly dividing it and placing it into different storage rooms. Only one regular scoring was attempted. This perhaps may be open to criticism, but in the opinion of the judges at the time the scoring was done it was quite evident that the cheese had just about arrived at its prime condition. Some of the cheese held for two weeks in the factory curing room and then placed in the 40-degree room had advanced a little too far, in the opinion of one of the judges, and was marked off

accordingly. On the other hand, the cheese which went direct into the 32-degree room from the hoop was sometimes a little too mild to suit the other judges, so the differences about balanced themselves in this respect. In previous tests made at other places a number of scorings had been made, but it was impossible to show from an inspection of the records just what was gained by this extra work and expense.

EFFECT OF PARAFFINING AND TEMPERATURE ON WEIGHT.

The greater part of the cheese was weighed, the only exception being with the first lots, which went into the cold rooms direct from the hoop, as the scales for use at the storage house, though ordered in ample time, had not arrived. A good pair of scales was in use at the factory, and all the cheese paraffined before going into storage was weighed. The cheese was weighed at three different periods—as it came from the press, at the time it was paraffined, and finally at the time it was scored. The weights of the duplicates only are given in the following table, as the plugging made a difference in the weight of the cheese plugged for scoring:

TABLE II.—*Weights of cheese at different periods.*

LOW RENNET.

Lot.	Factory cured.		In 32-degree room from hoops.			In 40-degree room from hoops.			In 32-degree room at one week.			In 40-degree room at one week.			In 32-degree room at two weeks.			In 40-degree room at two weeks.		
	Fresh from press.	When ripe.	Fresh from press.	When paraffined.	When scored.	Fresh from press.	When paraffined.	When scored.	Fresh from press.	When put in storage.	When scored.	Fresh from press.	When put in storage.	When scored.	Fresh from press.	When put in storage.	When scored.	Fresh from press.	When put in storage.	When scored.
	Lbs. oz.	*Lbs. oz.*	*Lbs. z.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*
1	19 3	17 5	19 14	....	19 2	19 11	....	18 15	19 7	18 15	18 14	19 13	19 5	19 2	19 6	18 9	18 8	19 8	18 13	18 9
2	19 12	17 14	....	....	....	....	....	....	19 13	19 7	19 6	19 13	19 7	19 3	19 12	19 1	19 1	19 8	18 12	18 10
3	19 10	17 13	....	....	....	....	....	....	19 15	19 8	19 7	19 12	19 4	18 15	19 3	18 4	18 4	19 12	18 12	18 9
4	19 14	18 0	....	....	....	....	....	....	19 10	19 4	19 4	19 6	19 1	18 15	....	....	....	....	....	....
5	19 4	17 12	....	....	....	....	....	....	19 14	19 1	18 14	19 10	19 3	18 14	19 10	18 15	18 13	19 3	18 8	18 2
6	19 8	17 13	....	....	....	....	....	....	19 7	18 15	18 14	19 8	19 0	18 12	19 7	18 9	18 8	19 6	18 8	18 4
7	19 6	17 14	....	....	....	....	....	....	19 7	18 15	18 14	19 3	18 11	18 7	19 6	18 11	18 3	19 5	18 8	18 4
8	19 9	18 0	....	....	....	....	....	....	19 8	18 15	18 14	19 9	19 1	18 12	19 10	18 15	18 13	19 11	18 15	18 9
10	19 11	18 9	19 12	19 4	19 4	19 6	18 15	18 14	19 9	....	19 0	19 9	19 3	18 12	19 7	18 11	18 8	19 11	18 14	18 11
11	19 7	18 9	19 13	19 7	19 7	19 10	19 4	19 4	19 10	19 3	19 2	19 9	19 2	19 2	19 6	18 12	18 11	19 5	18 9	18 6
12	19 10	18 12	19 5	18 15	18 15	19 8	19 2	19 2	19 0	18 8	18 7	19 2	18 10	18 5	19 4	18 8	18 6	19 6	18 10	18 6
13	18 8	17 15	19 7	18 12	18 10	19 10	19 2	19 2	19 9	19 2	19 1	19 12	19 4	19 1	19 7	18 11	18 10	19 9	18 14	18 11
14	19 11	19 0	19 9	18 15	18 13	19 8	19 4	19 3	19 9	19 4	19 2	19 13	19 8	19 7	19 8	18 14	18 14	19 13	19 2	19 0
15	19 14	18 15	19 14	19 3	19 2	19 15	19 10	19 8	19 9	19 1	19 0	19 13	19 5	19 4	19 8	18 13	18 12	19 14	19 2	19 0
16	19 11	18 15	19 12	19 2	19 0	19 7	19 1	19 0	19 11	19 2	19 2	19 12	19 2	19 0	19 11	18 14	18 14	19 9	18 13	18 11

HIGH RENNET.

Lot.	Factory cured: Fresh from press.	Factory cured: When ripe.	32° hoops: Fresh from press.	32° hoops: When paraffined.	32° hoops: When scored.	40° hoops: Fresh from press.	40° hoops: When paraffined.	40° hoops: When scored.	32° one week: Fresh from press.	32° one week: When put in storage.	32° one week: When scored.	40° one week: Fresh from press.	40° one week: When put in storage.	40° one week: When scored.	32° two weeks: Fresh from press.	32° two weeks: When put in storage.	32° two weeks: When scored.	40° two weeks: Fresh from press.	40° two weeks: When put in storage.	40° two weeks: When scored.
1	19 13	18 1	....	....	....	....	....	....	19 10	19 3	18 15	19 11	19 4	18 14	19 13	19 0	18 14	20 1	19 4	19 1
2	19 11	18 1	....	....	....	....	....	....	19 13	19 4	19 2	19 11	18 15	18 12	19 13	19 2	19 0	19 11	19 1	18 11
3	19 6	17 12	....	....	....	....	....	....	19 4	18 13	18 11	19 1	18 6	18 4	19 2	18 6	18 4	19 1	18 4	18 4
5	19 9	18 11	19 14	19 5	19 0	19 7	19 1	19 1	19 7	19 2	18 14	19 12	19 6	19 6	19 9	18 14	18 13	19 6	18 12	18 9
6	19 12	18 10	19 6	18 14	18 14	19 12	19 5	19 5	19 12	19 6	19 6	19 8	19 1	19 1	19 15	19 4	19 3	19 13	19 2	18 15
7	19 10	18 10	19 9	19 2	19 0	19 12	19 2	19 0	19 10	19 3	19 2	19 11	19 5	19 1	19 10	18 14	18 13	19 12	19 0	18 14
8	19 13	18 12	19 11	19 4	18 13	19 13	19 3	18 15	19 15	19 8	19 7	19 13	19 6	19 4	19 9	18 14	18 13	19 12	19 2	18 12
9	19 0	18 2	19 10	19 3	19 1	19 6	19 0	18 14	19 4	18 13	18 9	19 5	18 15	18 12	19 16	18 11	18 8	19 8	18 14	18 9
10	19 10	18 12	19 6	18 9	18 8	19 6	19 2	19 1	19 2	18 11	18 9	19 3	18 13	18 11	19 1	18 7	18 4	19 5	18 11	18 6
11	19 11	18 13	19 4	18 14	18 12	19 7	19 1	18 14	19 8	19 1	18 15	19 8	19 2	19 0	19 2	18 6	18 4	19 8	18 11	18 6
12	19 10	18 12	19 7	19 1	18 14	19 13	19 8	19 7	19 10	19 1	19 0	19 8	19 0	18 14	19 11	18 14	18 14	19 10	18 14	18 12
Average loss both lots	....	1 3	....	0 8½	0 10	....	0 6	0 7	....	0 7½	0 9	....	0 7½	0 10	....	0 12	0 13	....	0 12	0 15½

With the cheese which went into storage direct from the hoop the paraffining or weighing was not done at any particular time or stated period after coming from the hoop. The cheese was closely observed and was paraffined when it had commenced to mold. The time, of course, was longer for the cheese placed in the 32-degree room than for that in the 40-degree room. The cheese placed direct from the hoop into the cold rooms did not color up as rapidly as when kept in the factory, hence the paraffining was delayed as long as possible. It was thought that the paraffining might have some undesirable effect in preventing the desired coloration in the fresh cheese. On the other hand it was believed that the delay in paraffining, when the cheese was kept in a cold and almost saturated atmosphere, could not have had any bad effect other than in allowing mold to grow.

As has been stated, the influence of temperature on shrinkage is not so important since the adoption of paraffining as it was in the beginning of cold-curing experiments. The loss of weight under the paraffin is very slight, sometimes the cheese weighing as much five months after going into storage as when first paraffined. The interesting feature of the weight of the cheese in these experiments, as given in Table II, was the effect on the loss of holding the cheese from one to two weeks before paraffining and storing, as was done in the regular line of the experiment.

The table shows that there was an average loss of 1 pound 3 ounces per cheese in the cheese kept in the factory curing room until thoroughly cured. The average loss of the cheese put direct into the cold room from the hoops indicates that there was a greater loss in the 32-degree room than in the 40-degree room both before and after paraffining. As the cheese was held longer in the former room before paraffining, the greater loss during this period might be expected, but no satisfactory explanation can be given of the greater loss after paraffining. With the cheese put into the cold rooms at one and two weeks of age the 32-degree room gave less average shrinkage in both cases. This would be the expected result.

The most interesting feature of the results is the decided saving in weight by putting cheese in storage at one week of age rather than at two weeks of age. This saving amounted to 4 ounces per cheese in the 32-degree room and 5 ounces per cheese in the 40-degree room. This, while seemingly small, is enough of a saving to interest both makers and dealers who handle large lots of cheese. If the weight lost before paraffining could be added, it would be an important item, an amount worth attempting to save if this could be done without injury to the quality of the cheese. At the present time it is considered impossible successfully to paraffin and store a cheese fresh from the press. Some work has been done along this line, but the results need further experimental demonstration. It might be said, however, that it will

probably be found that cheese can be paraffined as it comes from the hoop if it is expected to hold the cheese two months before selling. Otherwise the cheese would not color up as desired, but would remain a pale whitish color, which would undoubtedly injure its market price under present standards.

In considering the great variation in weights of individual cheeses, as shown in Table II, many things are found which are difficult to explain. In many cases there was no loss whatever from the time of paraffining to the time of the last weighing and scoring, these dates being from five to seven months apart. In one or two cases there was a loss of 8 ounces per cheese, and in a number of cases 6 ounces were lost. This is a wide range, and the only explanation is that there was a difference in the paraffining. The paraffin may be applied at a very high temperature, in which case a very thin coating is left on the surface of the cheese. This effects a saving in paraffin, and for various reasons makes a much neater appearance. But it appears that mold will grow through the thin paraffin, and it is probable that the thin coat allows a considerable amount of moisture to escape. This particular point should be determined by experimental tests, as it is a question of considerable importance. The writer hopes to get some further information on this subject, as well as concerning the practicability of paraffining cheese fresh from the press. In present practice the temperature of paraffining tanks is not regulated in any manner. Though nearly all cheese is paraffined, the practice is still in its infancy and little is known about its finer points.

SCORES OF THE CHEESE.

As previously stated, the cheese in these experiments was scored only once, and this scoring was done January 6. The numerical and descriptive scores of the different judges is given in Tables III and IV. The scores of the factory-cured cheese are shown in Table V. Table VI gives the average total scores.

TABLE III.—*Detailed numerical and descriptive scores of low-rennet cold-cured cheese.*

CHEESE STORED AT 32° F.

Age of cheese when stored.	Judge.	Numerical score.					Descriptive score.			
		Flavor.	Texture.	Color.	Make-up.	Total.	Flavor.	Texture.	Color.	Remarks.
Lot 1.										
Fresh	B.	41	28	15	10	94	Tainted	Gas holes	Straight	
	S.	41	26	15	10	92		do		
	W.	42	26	15	10	93	Flat	do	Straight	
Average		41.3	26.7	15	10	93				
One week	B.	36	25.5	15	10	86.5	Tainted	Gas holes	Straight	
	S.	39	25	15	10	89	do	Gas holes; loose		
	W.	38	25	15	10	88	do	Gas holes	Straight	
Average		37.7	25.2	15	10	87.9				
Two weeks	B.	36	25	14	10	85	Tainted	Gas holes	Slightly wavy	
	S.	40	25	15	10	90	do	do		
	W.	38	23	15	10	86	Flavory	Pin holes	Straight	
Average		38	24.3	14.6	10	87				
Lot 2.										
Fresh	B.	43.5	29.5	15	10	98	Clean	Smooth	Straight	
	S.	44	28	15	10	97				
	W.	44	28	15	10	97	Clean	Close; waxy	Straight	
Average		43.8	28.5	15	10	97.3				
One week	B.	42	29	15	10	96		Stiff	Straight	
	S.	43	28	15	10	96				
	W.	42	28	15	10	95	Flat	Close; waxy	Straight	
Average		42.3	28.3	15	10	95.6				
Two weeks	B.	43	28	15	10	96		Holes; stiff	Straight	
	S.	42	28	15	10	95				
	W.	42	27	14	10	93	Flat	Holes; stiff	Shade wavy	
Average		42.3	27.7	14.6	10	94.6				
Lot 3.										
Fresh	B.	44	29.5	15	10	98.5	Clean	Close; wavy	White specks	
	S.	42	28	15	10	95	Flat			

	W.	44	27	15	10	96	Clean	Silky; weak	Straight	Paraffined cold; mold grew under.
Average		43.3	28.3	15	10	96.6				
One week	B.	42	29	15	10	96		Close; waxy	Straight	
	S.	41	28	15	10	94				
	W.	44	29	15	10	98	Clean	Silky	Straight	
Average		42.3	28.7	15	10	96				
Two weeks	B.	43	29	15	10	97	Clean flat	Stiff	Straight	
	S.	43	28	15	10	96	Flat			
	W.	44	29	15	10	98	Clean	Silky	Straight	
Average		43.3	28.7	15	10	97				
Lot 4.										
Fresh	B.	42	29.5	15	10	96.5	Flat	Slightly weak; waxy	Straight	
	S.	41	28	15	10	94	do	Loose		
	W.	43	27	14	10	94	do	Waxy	Straight	
Average		42	28.2	14.6	10	94.8				
One week	B.	42	29.5	15	10	96.5	High	Smooth; waxy; close	White specks	
	S.	39	28	15	10	92	Tainted			
	W.	43	28	14	10	95		Waxy	Straight	
Average		41.3	28.5	14.6	10	94.4				
Two weeks	B.	43.5	29.5	15	10	98	Clean	Smooth; silky	Straight	
	S.	41	28	15	10	94	Flat	Loose		Moldy outside.
	W.	43	29	15	10	97	do	Close; waxy	Straight	
Average		42.5	28.8	15	10	96.3				
Lot 5.										
Fresh	B.	41.5	29	15	10	95.5	Flat	Smooth; waxy	Straight	
	S.	42	28	15	10	95				
	W.	41	27	15	10	93	Flat	Close; weak	Straight	
Average		41.5	28	15	10	94.5				
One week	B.	39	27.5	15	10	91.5	Off flavor	Stiff; mealy	Straight	
	S.	40	27	15	10	92		Gritty		
	W.	40	29	15	10	94	Off flavor	Close; waxy	Straight	
Average		39.6	27.8	15	10	92.5				

TABLE III.—*Detailed numerical and descriptive scores of low-rennet cold-cured cheese*—Continued.

CHEESE STORED AT 32° F.—Continued.

Age of cheese when stored.	Judge.	Numerical score.					Descriptive score.			
		Flavor.	Texture.	Color.	Make-up.	Total.	Flavor.	Texture.	Color.	Remarks.
Lot 6.										
Fresh	B.	44	29.5	15	10	98.5	Clean	Silky; waxy	Perfect	
	S.	43	28	15	10	96	Flat			
	W.	44	28	15	10	97	Clean	Silky	Straight	
Average		43.6	28.5	15	10	97.1				
One week	B.	43	29.5	15	10	97.5	Clean	Smooth; waxy	Perfect; straight	
	S.	43	28	15	10	96	Flat			
	W.	44	29	15	10	98	Clean	Waxy	Straight	
Average		43.3	28.8	15	10	97.1				
Two weeks	B.	42	27	14	10	93	Clean	Holes; loose	Slightly wavy	
	S.	42	27	14.5	10	93.5	Flat			
	W.	42	28	14	10	94	Flat; bitter	Waxy	Straight	
Average		42	27.3	14.1	10	93.5				
Lot 7.										
Fresh	B.	43.5	29.5	15	10	98	Clean	Silky; waxy	Straight	
	S.	41	27	14	10	92	Flat		Faded	
	W.	44	29	15	10	98	Clean	Waxy	Straight	
Average		42.8	28.5	14.6	10	96				
One week	B.	40	29	14.5	10	93.5	Slightly bitter; slight taint.	Mealy	Slightly wavy	
	S.	39	26	14	10	89	Too high acid	Mealy; gritty	Acid cut; faded	
	W.	40	28	14	10	92	Flat; acid	Gritty; waxy	Faded slightly	
Average		39.6	27.6	14.1	10	91.3				
Two weeks	B.	42	27.5	15	10	94.5	Slight taint	Gritty	Straight	
	S.	40	27	14	10	91			Faded	
	W.	43	28	14	10	95	Clean	Holes; waxy	Slightly faded	
Average		41.6	27.5	14.3	10	93.4				
Lot 8.										
Fresh	B.	41	28.5	15	10	94.5	Slight acid	Smooth; stiff		

	S.	41	26	14	10	91	Too high acid	Mealy	Acid cut
	W.	42	27	12	10	91	Acid; flat	Gritty	Faded some
Average		41.3	27.1	13.6	10	92.2			
One week	B.	40	27	15	10	92	Not clean	Stiff; mealy	
	S.	40	26	14	10	90	Too high acid	Mealy	Faded
	W.	39	24	12	10	85	Acid	do	do
Average		39.6	25.6	13.6	10	89			
Two weeks	B.	40	26	13	10	89	Too high acid	Mealy; gritty	Acid cut; faded
	S.	39	25	15	10	89	do	Mealy; stiff	Straight
	W.	43	25	12	10	90	Acid; flat	Mealy; gritty	Slightly faded
Average		40.6	25.3	13.3	10	89.2			
Lot 10.									
Fresh	S.	42.5	28	15	10	95.5	Flat	Loose	
	W.	43	29	15	10	97	Clean	Silky	Straight
Average		42.7	28.5	15	10	96.2			
One week	S.	42	28	15	10	95	Flat		
	W.	43	28	14	10	95	do	Waxy	Slightly faded
Average		42.5	28	14.5	10	95			
Two weeks	S.	41	26	15	10	92	Flat	Holes; loose	
	W.	41	28	14	10	93	Flat; shade bitter	Waxy	Slightly faded
Average		41	27	14.5	10	92.5			
Lot 11.									
Fresh	S.	40	28	14	10	92	Flat		
	W.	44	29	13	10	96	Clean	Holes; silky	Wavy
Average		42	28.5	13.5	10	94			
One week	S.	40	27	15	10	92	Flat		
	W.	44	29	14	10	97	Clean	Silky	Shade wavy
Average		42	28	14.5	10	94.5			
Two weeks	S.	42	28	15	10	95			
	W.	44	29	15	10	98	Clean	Holes; waxy	Straight
Average		43	28.5	15	10	96.5			

TABLE III.—*Detailed numerical and descriptive scores of low-rennet cold-cured cheese*—Continued.

CHEESE STORED AT 32° F.—Continued.

Age of cheese when stored.	Judge.	Numerical score.					Descriptive score.			
		Flavor.	Texture.	Color.	Make-up.	Total.	Flavor.	Texture.	Color.	Remarks.
Lot 12.										
Fresh	B.	44	29.5	15	10	98.5	Clean	Smooth; waxy		
	S.	42	27.5	15	10	94.5	Flat			
	W.	44	29	15	10	98	Clean	Smooth; waxy	Straight	
Average		43.3	28.6	15	10	96.9				
One week	B.	39	28	14	10	91	Bitter; flat	Smooth	Wavy	
	S.	42	27	14	10	93	Flat		Faded	
	W.	43	28	14	10	95	do	Holes; waxy	Slightly faded	
Average		41.3	27.6	14	10	93				
Two weeks	B.	43	28.5	15	10	96.5	Clean	Smooth	Perfect	
	S.	41	27	15	10	93			Faded	
	W.	43	29	15	10	97	Flat	Waxy	Faded some	
Average		42.3	28.1	15	10	95.5				
Lot 13.										
Fresh	S.	42.5	27	14.5	10	94	Flat; too high acid		Faded	
	W.	41	27	12	10	90	Shade acid	Mealy	Slightly faded	
Average		41.7	27	13.2	10	92				
One week	S.	41	27	14	10	92	Flat; too high acid	Mealy	Faded	
	W.	43	27	14	10	94	Clean	Holes; waxy	Straight	
Average		42	27	14	10	93				
Two weeks	S.	42	27	14.5	10	93.5	Flat		Faded	
	W.	41	26	14	10	91	Acid; flat; shade bitter.	Gritty	Straight	
Average		41.5	26.5	14.2	10	92.2				
Lot 14.										
Fresh	S.	43	27	15	10	95	Flat	Loose		Not paraffined.
	W.	42	28	15	10	95	do	Waxy	Slightly faded; wavy	
Average		42.5	27.5	15	10	95				

One week	S.	42	26	15	10	93	Flat	Loose		Soft rind.
	W.	42	28	15	10	95	do	Holes; waxy		
Average		42	27	15	10	94				
Two weeks	S.	41	26	15	10	92	Too high acid	Loose	Faded	
	W.	42	28	15	10	95	Flat	Smooth	Straight	
Average		41.5	27	15	10	93.5				
Lot 15.										
Fresh	B.	42	29	15	10	96	Off flavor	Smooth	Straight	
	S.	41	28	15	10	94	Flat			
	W.	43	28	15	10	96	do	Close; waxy	Straight	
Average		42	28.3	15	10	95.3				
One week	B.	40	27	15	10	92	Tainted; off flavor	Pasty	Straight	
	S.	40	27	15	10	92	Ripe	Gritty		
	W.	42	28	15	10	95	Flat	Close; waxy	Straight	
Average		40.6	27.6	15	10	93				
Two weeks	B.	42	28.5	15	10	95.5	Off flavor	Holes; mealy	Straight	
	S.	40	27	15	10	92	Ripe	Tallowy		
	W.	42	29	15	10	96	Flat	Close; waxy; smooth	Straight	
Average		41.3	28.1	15	10	94.4				
Lot 16.										
Fresh	S.	42	28	15	10	95	Flat	Loose		Not paraffined.
	W.	43	28	15	10	96	Clean	Waxy	Straight	
Average		42.5	28	15	10	95.5				
One week	S.	40	27	14.5	10	91.5	Flat	Loose; mealy	Faded	
	W.	41	26	14	10	91	do	Holes; gritty	Straight	
Average		40.5	26.5	14.2	10	91.2				
Two weeks	S.	39	26	14	10	89	Tainted; too high acid	Holes; mealy	Faded	
	W.	40	25	13	10	88	Flat	Mealy	White specks; wavy	
Average		39.5	25.5	13.5	10	88.5				

TABLE III.—*Detailed numerical and descriptive scores of low-rennet cold-cured cheese*—Continued.

CHEESE STORED AT 40° F.

Age of cheese when stored.	Judge.	Numerical score.					Descriptive score.			
		Flavor.	Texture.	Color.	Make-up.	Total.	Flavor.	Texture.	Color.	Remarks.
Lot 1.										
Fresh	B.	40	28	15	10	93	Tainted	Gas holes	Straight	
	S.	40	26	15	10	91	....do	Loose		
	W.	41	24	14	10	89	Low	Loose; holes	Straight	
Average		40.3	26	14.6	10	91				
One week	B.	35	25	15	10	85	Tainted	Tallowy; gas holes	Straight	
	S.	37	26	15	10	88	....do	Pasty; gas holes		
	W.	38	22	15	10	85	Off flavor	Gas holes; loose	Straight	
Average		36.7	24.3	15	10	86				
Two weeks	B.	35	25	15	10	85	Tainted	Gas holes	Straight	
	S.	36	26	15	10	87	Overripe; tainted	Gas holes; loose		
	W.	37	24	15	10	86	Off flavor; wheyshows	....do	Straight	
Average		36	25	15	10	86				
Lot 2.										
Fresh	B.	43.5	29	15	10	97.5		Smooth	Straight	
	S.	43	28	15	10	96				Bad rind.
	W.	43	28	15	10	96	Clean	Close; waxy	Straight	
Average		43.2	28.6	15	10	98.5				
One week	B.	41	28	15	10	94	Slightly tainted	Stiff	Straight	
	S.	40	27	15	10	92		Gritty		
	W.	42	28	15	10	94	Flat	Close; waxy	Straight	
Average		41	27.7	15	10	93.7				
Two weeks	B.	42	28	15	10	95	Flat	Stiff	Straight	
	S.	42	27	15	10	94		....do		
	W.	43	28	14	10	95	Clean	Holes; waxy	Wavy	
Average		42.3	27.7	14.6	10	94.6				
Lot 3.										
Fresh	B.	44	29.5	15	10	98.5	Clean	Smooth; silky	Straight	
	S.	42.5	28	15	10	95.5	Flat			Bad rind.

	W.	44	29	15	10	98	Clean	Silky	Straight	Paraffined cold; mold under rind.
Average		43.5	28.8	15	10	97.3				
One week	B.	41	29	15	10	95	Flat	Smooth	White specks	
	S.	39	27	15	10	91	Tainted	Loose		
	W.	43	29	13	10	95	Flat	Waxy	White specks	
Average		41	28.3	14.3	10	93.6				
Two weeks	B.	44	29	15	10	98	Clean; high	Smooth	Straight	
	S.	42	27	15	10	94		Loose		
	W.	44	29	15	10	98	Clean	Waxy	Straight	
Average		43.3	28.3	15	10	96.6				
Lot 4.										
Fresh	B.	43	30	15	10	98	Flat	Smooth; silky; waxy	Straight	Paraffined cold; mold grew under paraffin very bad.
	S.	40	28	15	10	93	do			
	W.	43	28	15	10	96	do	Silky	Straight	
Average		42	28.6	15	10	95.6				
One week	B.	42.5	29	15	10	96.5	Not clean; slight taint	Waxy	White specks	
	S.	38	26	15	10	89	Tainted	Loose		
	W.	42	28	15	10	95	Flat	Waxy	Straight	
Average		40.8	27.7	15	10	93.5				
Two weeks	B.	42	28.5	15	10	95.5	Flat	Mechanical holes		Moldy.
	S.	37	25	15	10	87	Tainted	Loose; gritty		Do.
	W.	42	27	15	10	94	Flat	Loose holes; waxy	Straight	
Average		40.3	26.8	15	10	92.1				
Lot 5.										
Fresh	B.	39	28	15	10	92	Off flavor; tainted	Smooth; close	Straight	
	S.	40	27	15	10	92	Not clean	Gritty		
	W.	39	28	15	10	92	Off flavor	Close; waxy	Straight	
Average		39.3	27.6	15	10	92				
One week	B.	39	28.5	15	10	92.5	Not clean	Close; stiff	Straight	
	S.	39	27	15	10	91	Tainted	Gritty		
	W.	40	28.5	15	10	93.5	Flat	Close; waxy	Straight	
Average		39.3	28	15	10	92.3				

TABLE III.—*Detailed numerical and descriptive scores of low-rennet cold-cured cheese*—Continued.

CHEESE STORED AT 40° F.—Continued.

Age of cheese when stored.	Judge.	Numerical score.					Descriptive score.			
		Flavor.	Texture.	Color.	Make-up.	Total.	Flavor.	Texture.	Color.	Remarks.
Lot 5—Continued.										
Two weeks	B.	39	27	14.5	10	90.5	Tainted	Loose; holes; stiff	Slightly wavy	
	S.	40	27	15	10	92	Tainted; ripe	Gritty		
	W.	41	27	14	10	92	Bitter	Holes; waxy	Straight	
Average		40	27	14.5	10	91.5				
Lot 6.										
Fresh	B.	44	29.5	15	10	98.5	Clean	Smooth; silky; waxy	Straight	
	S.	42	27	14	10	93	Flat	Loose	Faded	
	W.	43	28	14	10	95	do	Waxy	Slightly faded	
Average		43	28.1	14.3	10	95.5				
One week	B.	44	28	15	10	97	Slightly sharp; high	Holes; loose	Straight	
	S.	41	27	14.5	10	92.5	Too ripe	Loose	Faded	
	W.	43	28	12	10	93	Ripe	Holes; waxy	Straight	
Average		42.6	27.6	13.8	10	94.1				
Two weeks	B.	42	28	15	10	95	Clean; flat	Loose; holes; mealy	Straight	
	S.	42	26	14	10	92	Ripe	Mealy	Faded	
	W.	42	27	14	10	93	Flat	Loose; mealy	Straight	
Average		42	27	14.3	10	93.3				
Lot 7.										
Fresh	B.	40	29.5	15	10	94.5	Flat	Smooth; waxy		
	S.	40	27	14	10	91	do	Mealy	Faded	Badly paraffined.
	W.	40	26	13	10	89	Off flavor	Silky; weak	Slightly faded	
Average		40	27.5	14	10	91.5				
One week	B.	38	25	14	10	87	Bitter; too high acid	Mealy; gritty	Acid cut	
	S.	40	25	14	10	89	do	do	Too light; faded	
	W.	40	26	12	10	88	Acid	do	Faded	
Average		39.3	25.3	13.3	10	88				
Two weeks	B.	38	26	12	10	86	Slightly acidy	Holes; mealy	Mottled; acid cut	
	S.	38	25	13	10	86	Too high acid	Gritty; mealy	Too light; acid cut	

	W.	38	26	10	10	84	Acid; flavory	Mealy	Mottled; acid cut	
Average		38	25.6	11.6	10	85.2				
Lot 8.										
Fresh	B.	39	26	14	10	89	Too high acid	Tallowy; gritty	Faded	
	S.	40	26	14	10	90	do	Mealy	do	
	W.	41	26	13	10	90	Flat	do	Slightly faded	
Average		40	26	13.6	10	89.6				
One week	B.	30	24	10	10	74	High acid; sour	Mealy; gritty; close	Acid cut	
	S.	38	25	13	10	86	do	Mealy; gritty	Faded	
	W.	38	23	10	10	81	Acidy	Gritty	do	
Average		35.3	24	11	10	80.3				
Two weeks	B.	30	20	9	10	69	Tainted; too high acid	Tallowy; gritty; holes; loose	Mottled	
	S.	39	24	12	10	85	Too high acid	Mealy; gritty	Mottled; faded	
	W.	35	22	8	10	75	High acid	Tallowy	Mottled	
Average		34.6	22	9.6	10	76.2				
Lot 10.										
Fresh	S.	40	27	14.5	10	91.5	Off flavor	Loose; weak	Faded	Damaged under paraffin.
	W.	43	28	11	10	92	Flat	Waxy	Faded some	
Average		41.5	27.5	12.7	10	91.7				
One week	S.	41	27	14.5	10	92.5	Flat	Mealy		Moldy.
	W.	42	26	11	10	89	Low	Gritty	Streaked	
Average		41.5	26.5	12.6	10	90.6				
Two weeks	S.	40	27	14	10	91	Flat; bitter; too high acid.	Gritty	Faded	
	W.	40	25	11	10	86	Low	do	Faded (not bright)	
Average		40	26	12.5	10	88.5				
Lot 11.										
Fresh	S.	41	27	15	10	93	Flat	Holes		
	W.	44	30	15	9	98	Clean	Silky	Straight	
Average		42.5	28.5	15	9.5	95.5				
One week	S.	40	27	15	10	92	Too high acid			
	W.	44	28	15	10	97	Perfect	Holes; silky	Straight	
Average		42	27.5	15	10	94.5				

TABLE III.—*Detailed numerical and descriptive scores of low-rennet cold-cured cheese*—Continued.

CHEESE STORED AT 40° F.—Continued.

Age of cheese when stored.	Judge.	Numerical score.					Descriptive score.			
		Flavor.	Texture.	Color.	Make-up.	Total.	Flavor.	Texture.	Color.	Remarks.
Lot 11—Continued.										
Two weeks	S.	42	26	15	10	93	Too high acid		Wavy	
	W.	40	28	15	10	93	Flat	Waxy	do	
Average		41	27	15	10	93				
Lot 12.										
Fresh	S.	43	28	15	10	96	Flat			
	W.	43	28	14	10	95	Low	Waxy	Faded some	
Average		43	28	14.5	10	95.5				
One week	B.	41	29	15	10	95	Off flavor	Loose		
	S.	40	26	14	10	90	Off flavor; ripe	Loose; mealy	Faded	
	W.	41	28	14	10	93	Off flavor	Waxy	do	
Average		40.6	27.6	14.3	10	92.6				
Two weeks	B.	40	27	15	10	92	Sharp	Salvy		
	S.	41	26	14	10	91	Ripe; clean	Loose	Faded	
	W.	42	28	14	10	94	Ripe	Holes; waxy	Faded at holes	
Average		41	27	14.3	10	92.3				
Lot 13.										
Fresh	S.	41	26	14	10	91	Flat; too high acid	Mealy	Faded	
	W.	41	28	14	10	93	Flat	Waxy	Straight	
Average		41	27	14	10	92				
One week	S.	40	26	14	10	90	Flat; too high acid	Mealy	Faded	
	W.	42	27	14	10	93	Flat	Holes; waxy	Straight	
Average		41	26.5	14	10	91.5				
Two weeks	S.	40	26	14	10	90	Flat; too high acid	Mealy	Faded	
	W.	41	26	14	10	91	Bitter; flat	Gritty	Straight	
Average		40.5	26	14	10	90.5				
Lot 14.										
Fresh	S.	43	27	15	10	95	Flat	Loose		Soft rind; mold under paraffin.

	W.	44	28	15	10	97	High	Waxy	Straight
Average		43.5	27.5	15	10	96			
One week	S.	41	27	15	10	93	Bitter		
	W.	40	28	15	10	93	Low	Waxy	Straight
Average		40.5	27.5	15	10	93			
Two weeks	S.	40	26	15	10	91	Too ripe	Mealy	
	W.	41	26	14	10	91	Low	do	Slightly faded
Average		40.5	26	14.5	10	91			
Lot 15.									
Fresh	B.	38	28	15	10	91	Off flavor; tainted	Smooth	Straight
	S.	41	27	15	10	93	Flat	Loose	
	W.	41	29	15	10	95	do	Close; waxy	Straight
Average		40	28	15	10	93			
One week	B.	36	26	15	10	87	Off flavor; tainted	Tallowy; gritty	Straight
	S.	38	26	15	10	89	Overripe	Gritty	
	W.	40	28	15	10	93	Flavory	Close; waxy	Straight
Average		38	26.6	15	10	89.6			
Two weeks	B.	39	26	15	10	90	Off flavor	Tallowy; gritty	Straight
	S.	40	26	15	10	91	Ripe	Mealy; gritty	
	W.	38	25	15	10	88	Off flavor	Close; tallowy	Straight
Average		39	25.6	15	10	89.6			
Lot 16.									
Fresh	S.	39	27	14	10	90	Tainted		Faded
	W.	40	25	15	10	90	Flat	Weak	Straight
Average		39.5	26	14.5	10	90			
One week	S.	40	26	14	10	90	Tainted	Mealy	Faded
	W.	40	25	14	10	89	Flat	do	Slightly faded
Average		40	25.5	14	10	89.5			
Two weeks	S.	38	27	14	10	89	Tainted		Faded
	W.	40	25	14	10	89	Flat	Mealy	Slightly faded
Average		39	26	14	10	89			

NOTE.—Lot 1 stored at 32° and lot 1 stored at 40° F. came from the same vat, and the same is true of all other lots with the same numeral. This is also true with regard to the table of high-rennet cheese.

TABLE IV.—*Detailed numerical and descriptive scores of high-rennet cold-cured cheese.*

CHEESE STORED AT 32° F.

Age of cheese when stored.	Judge.	Numerical score.					Descriptive score.			
		Flavor.	Texture.	Color.	Make-up.	Total.	Flavor.	Texture.	Color.	Remarks.
Lot 1.										
Fresh	B.	42	29	15	10	96	Flat	Smooth; waxy; holes; loose.	Straight	
	S.	42	28	15	10	95	Flat; bitter			
	W.	44	28	14	10	96	Clean	Silky	Streaked; faded some	
Average		42.3	28.3	14.6	10	95.3				
One week	B.	39	28.5	15	10	92.5	Tainted	Smooth; loose	Straight	
	S.	40	25	15	10	90	Ripe	Swiss holes; loose		
	W.	40	28	14	10	92	Off flavor	Swiss holes; waxy	Streaked	
Average		39.6	27.1	14.6	10	91.5				
Two weeks	B.	39	29	15	10	93	Bitter; tainted	Holes; stiff	Straight	
	S.	41	26	15	10	92		Swiss holes; loose		
	W.	43	28	15	10	96	Flat	Gas holes; waxy	Straight	
Average		41	27.6	15	10	93.6				
Lot 2.										
Fresh	B.	43.5	29.5	15	10	98	Flat	Smooth; silky	Straight	
	S.	42	28	15	10	95	do			
	W.	43	28	15	10	96	do	Close; waxy	Straight	
Average		42.8	28.5	15	10	96.3				
One week	B.	42	29	15	10	96	Slight taint	Gritty; holes; stiff	Straight	
	S.	41	27	15	10	93	Ripe	Weak		
	W.	43	28	15	10	96	Flat	Close; waxy	Straight	
Average		42	28	15	10	95				
Two weeks	B.	41	28.5	15	10	94.5	Slightly tainted	Mealy; loose	Straight	
	S.	40	26	15	10	91	Ripe; bitter	Loose; weak		
	W.	43	28	15	10	96	Flat	Loose; holes	Straight	
Average		41.3	27.5	15	10	93.8				
Lot 3.										
Fresh	B.	42	29	14	10	95	Bitter	Loose; waxy	Faded	
	S.	41	27	15	10	93	Flat			Bad rind.

	W.	42	28	14	10	94	Flat; bitter	Waxy	Faded some
Average		41.6	28	14.3	10	94			
One week	B.	40	29	15	10	94	Slight taint	Gritty	Straight
	S.	39	27	15	10	91	Tainted	Loose	
	W.	42	28	14	10	94	Flat	Waxy	Too light
Average		40.3	28	14.6	10	93			
Two weeks	B.	39	28	14.5	10	91.5	Tainted; bitter	Mealy	Faded
	S.	37	26	14	10	87	do	do	do
	W.	42	27	13	10	92	Some bitter	Loose; waxy	Faded some
Average		39.3	27	13.8	10	90.1			
Lot 5.									
Fresh	B.	43	29	15	10	97	Clean; flat	Smooth; weak	Straight
	S.	42	28	15	10	95			
	W.	43	29	15	10	97	Clean	Close; waxy	Straight
Average		42.6	28.6	15	10	96.3			
One week	B.	41.5	29	15	10	95.5	Tainted; not clean	Smooth; waxy	Straight
	S.	41	27.5	15	10	93.5	Not clean; flat	Loose	
	W.	42	28	15	10	95	Clean	Smooth; close	Straight
Average		41.5	28.1	15	10	94.6			
Two weeks	B.	41	28	15	10	94	Tainted; not clean	Mechanical holes; smooth; waxy.	White specks
	S.	40	27	15	10	92	Not clean	Loose	
	W.	42	27	15	10	94	Flat	Loose; holes; waxy	Straight
Average		41	27.3	15	10	93.3			
Lot 6.									
Fresh	B.	39.5	27.5	11	10	88	Tainted; bitter	Tallowy; pasty	Mottled
	S.	40	25	15	10	90	Very bitter	Loose	do
	W.	41	27	8	10	86	Shade bitter	Loose; pasty	do
Average		40.1	26.5	11.3	10	88			
Two weeks	B.	38	26	11	10	85	Tainted; bitter	Tallowy; pasty; loose	Mottled
	S.	39	26	12	10	87	do	Weak	do
	W.	39	25	8	10	82	Flavory; bitter	Pasty; loose	do
Average		38.6	25.6	10.3	10	84.5			

TABLE IV.—*Detailed numerical and descriptive scores of high-rennet cold-cured cheese*—Continued.

CHEESE STORED AT 32° F.—Continued.

Age of cheese when stored.	Judge.	Numerical score.					Descriptive score.			Remarks.
		Flavor.	Texture.	Color.	Make-up.	Total.	Flavor.	Texture.	Color.	
Lot 7.										
Fresh	B.	43.5	30	15	10	98.5	Clean; high	Smooth; waxy	Straight	
	S.	42	28.5	15	10	95.5	Flat; bitter			
	W.	44	28	14	10	96	Clean	Close; waxy	Straight	
Average		43.1	28.8	14.6	10	96.6				
One week	B.	42	29.5	15	10	96.5	Flat	Smooth; waxy	Straight	
	S.	41	27	15	10	93	do	Loose		
	W.	42	28	14	10	94	Flat; ripe	Holes; silky; close; smooth	Straight	
Average		41.6	28.1	14.6	10	94.5				
Two weeks	B.	42	29.5	15	10	96.5	Slight taint	Smooth; loose; waxy	Straight	
	S.	41	27	15	10	93		Loose		
	W.	42	29	14	10	95	Flat	Holes; close; smooth; silky	Straight	
Average		41.6	28.5	14.6	10	94.8				
Lot 8.										
Fresh	B.	44	29.5	15	10	98.5	Clean; high	Smooth; silky; waxy	Straight	
	S.	43.5	28.5	15	10	97		Loose		
	W.	44	29	15	10	98	Clean; ripe	Close; silky	Straight	
Average		43.8	29	15	10	97.8				
One week	B.	43.5	29.5	15	10	98	Clean; high	Smooth; silky; waxy	Straight; white specks	
	S.	42	27.5	14	10	93.5	Flat	Loose	White specks	
	W.	43	28	12	10	93	Clean	Close; waxy	White specks; faded	
Average		42.8	28.3	13.6	10	94.8				
Two weeks	B.	43.5	29.5	15	10	98	Clean; high	Smooth; silky	Straight	
	S.	43	28	15	10	96				
	W.	43	29	15	10	97	Clean	Close; waxy	Straight	
Average		43.1	28.8	15	10	97				
Lot 9.										
Fresh	B.	41	28.5	14	10	93.5	Flat; bitter	Loose; waxy; silky		
	S.	41	27	14	10	92	Flat	Weak	Faded	

	W.	43	28	13	10	94	Flat; ripe	Waxy	Slightly faded	
Average		41.6	27.8	13.6	10	93.2				
One week	B.	40	29	14.5	10	93.5	Tainted	Loose	Straight	
	S.	38	26	13	10	87	....do	Mealy	Too light; faded	
	W.	40	28	10	10	88	Bitter	Waxy	Faded	
Average		39.3	27.6	12.5	10	89.4				
Two weeks	B.	36	28	15	10	89	Tainted	Pasty; watery		
	S.	36	24	13	10	83	Tainted; bitter; too high acid.	Mealy	Mottled; faded; acid cut; too light.	
	W.	40	28	13	10	91	Acid; bitter	Waxy	Slightly faded	
Average		37.3	26.6	13.6	10	87.6				
Lot 10.										
Fresh	B.	39	26.5	15	10	90.5	Tainted	Pasty; weak	Straight	
	S.	41	26	15	10	92		....do		
	W.	43	25	15	10	93	Clean	Ripe; close; waxy	Straight	
Average		41	25.8	15	10	91.8				
Two weeks	B.	38	29	15	10	92	Tainted	Smooth; close; waxy	Straight	
	S.	40	27	15	10	92	Ripe	Weak		
	W.	39	28	15	10	92	Off flavor	Close; waxy	Too light	
Average		39	28	15	10	92				
Lot 11.										
Fresh	B.	43.5	30	15	10	98.5	Not clean	Smooth; silky	Straight	
	S.	40	27	14	10	91	Flat			Not paraffined.
	W.	42	26	14	10	92	....do	Smooth; close; meaty	Straight	
Average		41.8	27.6	14.3	10	93.8				
One week	B.	43.5	29.5	15	10	98		Smooth; silky	Straight	
	S.	40.5	27	14.5	10	92				
	W.	42	27	14	10	93	Flat	Close; ripe; silky	Straight	
Average		42	27.8	14.5	10	94.3				
Two weeks	B.	41	29.5	15	10	95.5	Tainted; whey flavor.	Smooth; waxy	Perfect	
	S.	36	30	15	10	91	Tainted; ripe	Weak	Faded	
	W.	40	26	14	10	90	Off flavor	Close; ripe; smooth	Straight	
Average		39	28.5	14.6	10	92.2				

TABLE IV.—*Detailed numerical and descriptive scores of high-rennet cold-cured cheese*—Continued.

CHEESE STORED AT 32° F.—Continued.

Age of cheese when stored.	Judge.	Numerical score. Flavor.	Numerical score. Texture.	Numerical score. Color.	Numerical score. Make-up.	Numerical score. Total.	Descriptive score. Flavor.	Descriptive score. Texture.	Descriptive score. Color.	Remarks.
Lot 12.										
Fresh	B.	43	30	15	10	98	Not quite clean	Perfect; smooth; silky	Perfect	
	S.	40	28	15	10	93	Flat	Weak		Not paraffined.
	W.	44	28	15	10	97	Clean	Close; meaty; silky	Straight	
Average		42.3	28.6	15	10	96				
One week	B.	42	29.5	15	10	96.5	Slightly bitter	Smooth; waxy	Perfect	
	S.	39	27	15	10	91	Tainted	Weak		
	W.	42	28	15	10	95	Off flavor; flat	Close; meaty; silky	Straight	
Average		41	28.3	15	10	94.3				
Two weeks	B.	39	28	15	10	92	Off flavor; tainted	Pasty; weak	Straight	
	S.	36	25	14	10	85	Tainted	Weak	Faded	
	W.	40	26	14	10	90	Off flavor; overripe	Close; waxy	Straight	
Average		38.3	26.3	14.3	10	89				

CHEESE STORED AT 40° F.

Age of cheese when stored.	Judge.	Numerical score. Flavor.	Numerical score. Texture.	Numerical score. Color.	Numerical score. Make-up.	Numerical score. Total.	Descriptive score. Flavor.	Descriptive score. Texture.	Descriptive score. Color.	Remarks.
Lot 1.										
Fresh	B.	42	29	15	10	96	Flat; clean	Smooth	Straight	Thick paraffin.
	S.	41	27	15	10	93	Flat	Loose		
	W.	44	28	15	10	97	Clean	Waxy	Straight	Cold paraffin; bad rind.
Average		42.3	28	15	10	95.3				
One week	B.	40	28	14	10	92	Not clean	Loose; gritty	Wavy	
	S.	41	28	15	10	94	Flat; bitter			
	W.	42	28	14	10	94	do	Holes; waxy	White specks	
Average		41	28	14.3	10	93.3				
Two weeks	B.	43	28	15	10	96	Flat	Gritty; holes; loose	Straight	
	S.	40	25	15	10	90	Flat; bitter	Loose		
	W.	43	27	15	10	95	Flat	Large mechanical holes; waxy.	Straight	
Average		42	26.6	15	10	93.6				

Lot 2.										
Fresh	B.	38	26	14	10	88	Tainted; bitter	Mealy; gritty; weak	Slightly wavy	
	S.	39	26	15	10	90	Tainted	Weak	Faded	
	W.	40	26	14	10	90	Bitter	Loose	Slightly faded	
Average		39	26	14.3	10	89.3				
One week	B.	39	28	14.5	10	91.5	Sharp; tainted	Gritty; holes; stiff	Slightly wavy	
	S.	37	25	15	10	87	Ripe; tainted; bitter	Weak; loose	Faded	
	W.	40	27	14	10	91	Off flavor	Close; gritty; waxy	Slightly faded	
Average		38.6	26.6	14.5	10	89.8				
Two weeks	B.	39	28	15	10	92	Bitter; tainted	Lumpy; tallowy; loose	Straight	
	S.	39	26	14	10	89	Tainted	Tallowy; weak	Faded	
	W.	42	27	15	10	94	Flat	Close; gritty; waxy	Straight	
Average		40	27	14.6	10	91.6				
Lot 3.										
Fresh	B.	38	28.5	15	10	91.5	Tainted; bitter	Stiff	Straight	
	S.	38	27	15	10	90	Tainted	Loose		
	W.	42	28	15	10	95	Flat	Waxy	Straight	Rind poor on account of paraffin.
Average		39.3	27.8	15	10	92.1				
One week	B.	35	28	15	10	88	Tainted	Loose; gritty	Straight	
	S.	37	26	15	10	88	Tainted; ripe	Mealy		
	W.	40	27	15	10	92	Off flavor; rancid	Waxy	Straight	
Average		37.3	27	15	10	89.3				
Two weeks	B.	37	29	15	10	91	Sharp; bitter	Stiff	Straight	
	S.	37	26	15	10	88	Ripe; tainted	Mealy		
	W.	42	28	14	10	94	Ripe; flat	Waxy	Faded some	
Average		38.6	28.3	14.6	10	91.				
Lot 5.										
Fresh	B.	42.5	29	15	10	96.5	Flat	Smooth; waxy	Straight	
	S.	42.5	28	15	10	95.5	do	Loose		
	W.	43	28	15	10	96	do	Close; smooth	Straight	
Average		42.6	28.3	15	10	96.				
One week	B.	40	27.5	15	10	92.5	Bitter; slightly tainted.	Smooth; waxy	Straight	
	S.	40	27	15	10	92	Tainted			
	W.	42	27	15	10	94	Flavory	Smooth; holes	Straight	
Average		40.6	27.2	15	10	92.8				

TABLE IV.—*Detailed numerical and descriptive scores of high-rennet cold-cured cheese*—Continued.

CHEESE STORED AT 40° F.—Continued.

Age of cheese when stored.	Judge.	Numerical score.					Descriptive score.			
		Flavor.	Texture.	Color.	Make-up.	Total.	Flavor.	Texture.	Color.	Remarks.
Lot 5—Continued.										
Two weeks	B.	41	28	15	10	94	Slight taint; not clean	Mealy; loose	Straight	
	S.	41	26	15	10	92		Loose		
	W.	41	27	15	10	93	Off flavor	Loose; waxy	Straight	
Average		41	27	15	10	93				
Lot 6.										
Fresh	B.	36	26	10	10	82	Tainted	Pasty; weak	Mottled	
	S.	36	26	10	10	82	do	Weak	Mottled; faded	
	W.	39	24	7	10	80	Flavory	Pasty	Mottled	
Average		27	25.3	9	10	81.3				
One week	B.	36	26	10	10	82	Tainted; bitter	Pasty; tallowy	Mottled	
	S.	37	25	12	10	84	do	Weak	do	
	W.	40	24	8	10	82	Flavory	Pasty; tallowy	do	
Average		37.6	25	10	10	82.6				
Two weeks	B.	38	26	11	10	85	Tainted; bitter	Pasty; tallowy	Mottled	
	S.	38	25	11	10	84	do	Weak	Mottled; faded	
	W.	40	26	8	10	84	Bitter	Pasty; tallowy	Mottled	
Average		38.6	25.6	10	10	84.2				
Lot 7.										
Fresh	B.	42	29.5	15	10	96.5	Starter	Smooth; silky; waxy	Straight	
	S.	41	28	15	10	94	Flat			
	W.	42	29	15	10	96	do	Silky; close	Straight	
Average		41.6	28.8	15	10	95.5				
One week	B.	43.5	29.5	15	10	98	Clean; high	Smooth; stiff	Straight	
	S.	42	28	15	10	95	Flat			
	W.	43	29	15	10	97	do	Close; waxy	Straight	
Average		42.8	28.8	15	10	96.6				
Two weeks	B.	39	29	15	10	93	Tainted	Stiff; loose	Straight	
	S.	42	28	15	10	95	Ripe			

	W.	42	29	15	10	96	Flat	Close; silky	Straight
Average		41	28.6	15	10	94.6			
Lot 8.									
Fresh	B.	44	29.5	15	10	98.5	Clean	Smooth; waxy	Straight
	S.	43	28.5	15	10	96.5			
	W.	43	29	15	10	97	Clean; ripe	Close; silky	Straight
Average		43.3	29	15	10	97.3			
One week	B.	43.5	29.5	14.5	10	97.5	High	Loose	Slightly wavy
	S.	42	27	15	10	94		do	
	W.	43	27	14	10	94	Flat	Waxy	Faded some
Average		42.8	27.8	14.5	10	95.2			
Two weeks	B.	42	29.5	15	10	96.5	Clean	Smooth; waxy	Straight
	S.	41	27	15	10	93	Ripe; bitter	Loose	
	W.	43	28	15	10	96	Ripe; clean	Close; waxy	Straight
Average		42	28.3	15	10	95.3			
Lot 9.									
Fresh	B.	40	27	14	10	91	Flat	Pasty; loose	Slightly wavy
	S.	40	26	13	10	89	do	Mealy	Too light
	W.	42	27	13	10	92	do	Waxy	do
Average		40.6	26.6	13.3	10	90.6			
One week	B.	37	28	14	10	89	Too high acid; bitter	Tallowy	Slightly wavy
	S.	39	25	13	10	87	do	Mealy	Too light; faded
	W.	41	27	13	10	91	Bitter	Mealy; tallowy	Too light
Average		39	26.6	13.3	10	89			
Two weeks	B.	37	24	12	10	83	Tainted	Gritty; loose	Wavy
	S.	39	25	13	10	87	Too high acid; bitter	Gritty; mealy	Too light; faded
	W.	42	27	13	10	91	Flat	Gritty	Too light
Average		39.3	25.3	12.6	10	87.2			
Lot 10.									
Fresh	B.	42	29	15	10	96	Not quite clean	Pasty	Straight
	S.	39	26	14	10	89	Ripe	Weak	Faded
	W.	44	29	15	10	98	Clean	Close; silky	Straight
Average		41.6	28	14.6	10	94.3			

TABLE IV.—*Detailed numerical and descriptive scores of high-rennet cold-cured cheese*—Continued.

CHEESE STORED AT 40° F.—Continued.

Age of cheese when stored.	Judge.	Numerical score.					Descriptive score.			
		Flavor.	Texture.	Color.	Make-up.	Total.	Flavor.	Texture.	Color.	Remarks.
Lot 10—Continued.										
One week	B.	37	26	15	10	88	Off flavor; tainted	Tallowy; holes; pasty	Straight	
	S.	39	26	14	10	89	Tainted	Pasty; weak	Faded	
	W.	42	27	14	10	93	Flat	Pasty; loose	Straight	
Average		39.3	26.3	14.3	10	90				
Two weeks	B.	37	25	14	10	86	Off flavor; tainted	Tallowy; holes; pasty	Wavy	
	S.	40	25	15	10	90	Tainted; ripe	Weak; pasty		
	W.	42	26	14	10	92	Flat	Loose; pasty	Straight	
Average		39.6	25.3	14.3	10	89.3				
Lot 11.										
Fresh	B.	40	29	15	10	94	Tainted; old milk	Smooth; waxy	Straight	
	S.	40	27	14	10	91	Tainted; bitter	Weak	Faded	
	W.	41	28	14	10	93	Bitter	Close; ripe; silky	Straight	Rind poor.
Average		40.3	28	14.3	10	92.6				
One week	B.	40.5	29.5	15	10	95	Whey flavor; old milk.	Smooth; waxy	Straight	
	S.	36	25	14	10	85	Tainted; bitter	Weak	Faded	
	W.	40	27	14	10	91	Off flavor	Close; ripe; smooth	Straight	
Average		38.8	27.2	14.3	10	90.3				
Two weeks	B.	38	27	14	10	89	Tainted	Gritty; weak	Faded	
	S.	39	29	15	10	93	do	Holes; mealy	White specks	
	W.	40	27	14	10	91	Off flavor	Close; smooth	Straight	
Average		39	27.6	14.3	10	91				
Lot 12.										
Fresh	B.	38	29.5	15	10	92.5	Tainted; bitter	Smooth; silky	Straight	
	S.	38	26	15	10	89	do	Loose		
	W.	40	28	15	10	93	Tainted	Loose; waxy	Straight	
Average		38.6	27.8	15	10	91.5				

One week	B.	38	29.5	15	10	92.5	Tainted; bitter	Waxy	Straight
	S.	38	26	15	10	89	Tainted	Weak	Faded
	W.	40	27	15	10	92	Off flavor	Close; silky	Straight
Average		38.6	27.5	15	10	91.1			
Two weeks	B.	37	28	15	10	90	Too high acid; tainted; bitter.	Pasty	Straight
	S.	37	26	15	10	88	Tainted	Weak	Faded
	W.	39	28	15	10	92	Off flavor	Close; silky	Straight
Average		37.6	27.3	15	10	90			

TABLE V.—*Scores of cheese cured in factory.*

LOW RENNET.

Lot.	Flavor.	Texture.	Color.	Make-up.	Total.	Flavor of cheese.	Texture.
1...	34	23	15	10	82	Sweet, heated........	Gritty; Swiss holes.
2...	34	20	15	10	79	Tainted..............	Stiff; mealy; loose.
3...	34	20	15	10	79	.....do...............	Do.
4...	33½	21½	15	10	80	Old milk.........	Gritty; mechanical holes.
5...	35½	21	15	10	81½	Tainted..............	Stiff; mealy.
6...	22	22	15	10	69	Tainted, dirty ..,....	Gritty; loose.
7...	26	20	15	10	71	Acid, tainted	Tallowy; loose.
8...	34	22	15	10	81	Acid.................	Mealy.
10...	29	27	15	10	81	Tainted, bitter	Smooth; close.
11...	37	26	15	10	88	Tainted..............	Salvy; gritty.
12...	42	24½	15	10	91½	Clean................	Gritty; loose.
13...	38	24½	15	10	87½	Heated...............	Salvy; close.
14...	35	23	15	10	83	Weedy...............	Do.
15...	38	24	15	10	87	....	Mealy; dry.
16...	34	21	15	10	80	Weedy...............	Dry; mealy.

HIGH RENNET.

Lot.	Flavor.	Texture.	Color.	Make-up.	Total.	Flavor of cheese.	Texture.
1...	37	24	15	10	86	Tainted..............	Salvy; gritty; loose.
2...	40½	28	15	10	93½	Heated...............	Stiff; close.
3...	33	24	15	10	82	Tainted..............	Pasty; loose.
5...	42½	29	15	10	96½	Clean................	Waxy; close.
6...	40½	27½	15	10	93	....	Dry; mechanical holes.
7...	42½	27½	15	10	95	....	Smooth; mechanical holes.
8...	41	28	15	10	94	Slightly bitter........	Waxy.
9...	30	22	15	10	77	Acid, bitter..........	Tallowy.
10...	42½	27	15	10	94½	Clean................	Mechanical holes.
11...	38	24½	15	10	87½	Bitter...............	Loose.
12...	43	29	15	10	97	Clean................	Close.

TABLE VI.—*Average total scores of cheese by lots.*

LOW RENNET.

Lot.	In 32-degree room from hoops.	In 40-degree room from hoops.	In 32-degree room at one week.	In 40-degree room at one week.	In 32-degree room at two weeks.	In 40-degree room at two weeks.	Cured at factory.
1................	93.0	91.0	87.9	86.7	87.0	86.0	82.0
2................	97.3	98.5	94.6	93.7	94.6	94.6	79.0
3................	96.6	97.3	96.0	93.6	97.0	96.6	79.0
4................	94.8	95.6	94.4	93.5	96.3	92.1	80.0
5................	94.5	92.0	92.5	92.3	....	91.5	81.5
6................	97.1	95.5	97.1	94.1	93.5	93.3	69.0
7................	96.0	91.5	91.3	88.0	93.4	85.2	71.0
8................	92.2	89.6	89.0	80.0	89.2	76.2	81.0
10................	96.2	91.7	95.0	90.6	92.5	88.5	81.0
11................	94.0	95.5	94.5	94.5	96.5	93.0	88.0
12................	96.9	95.5	93.0	92.6	95.5	92.3	91.5
13................	92.0	92.0	93.0	91.5	92.2	90.5	87.5
14................	95.0	96.0	94.0	93.0	93.5	91.0	83.0
15................	95.3	93.0	93.0	89.6	94.4	89.6	87.0
16................	95.5	90.0	91.2	89.5	88.5	89.0	80.0
Average.....	95.0+	94.3+	93.8+	90.0	93.0+	90.0	81.4

HIGH RENNET.

Lot.	In 32-degree room from hoops.	In 40-degree room from hoops.	In 32-degree room at one week.	In 40-degree room at one week.	In 32-degree room at two weeks.	In 40-degree room at two weeks.	Cured at factory.
1................	95.3	95.3	91.5	93.3	93.6	93.6	86.0
2................	96.3	89.3	95.0	89.8	93.8	91.6	93.5
3................	94.0	92.1	93.0	89.3	90.1	91.0	82.0
5................	96.3	96.0	94.6	92.8	93.3	93.0	96.5
6................	88.0	81.3	....	82.6	84.5	84.2	93.0
7................	96.6	95.5	94.5	96.6	94.8	94.6	95.0
8................	97.8	97.3	94.8	95.2	97.0	95.3	94.0
9................	93.2	90.6	89.4	89.0	87.6	87.2	77.0
10................	91.8	94.3	....	90.0	92.0	89.3	94.5
11................	93.8	92.6	94.3	90.3	92.2	91.0	87.5
12................	96.0	91.5	94.3	91.1	89.0	90.0	97.0
Average.....	94.4+	92.3	93.4	90.3	91.6	90.9	90.5

As shown by the general average in Table VI, the cheese put in the 32-degree room direct from the hoop gave the highest score, though the score was very little higher than that for the cheese placed in the 40-degree room at the same time. Of the lots of cheese placed in the cold rooms at 1 and 2 weeks of age, the 32-degree lot shows an advantage very marked in the low-rennet series and not quite so marked in the high-rennet series.

In the scores for the individual lots a number of cases are found where the cheese held in the 40-degree room is given the higher score. In lot 10 of the high-rennet cheese the cheese placed immediately in the 40-degree room scored on an average 2.5 points higher than the cheese placed in the 32-degree room. In a few other cases there was a difference of 2 points in favor of the 40-degree room. It will be noted that lot 10, to which attention is called, scored very evenly all the way through, getting a very good score on the cheese cured in the factory curing room. This was true in every other case where the cheese held at 40° F. scored as high as that kept at 32° F.

On the other hand, there were some instances of wide variation in scores in favor of the 32-degree temperature. As an example, lot 7, low-rennet cheese, 2 weeks of age at time of scoring, shows a variation of 8 points in favor of the 32-degree room. Lot 8, low-rennet cheese, shows a variation all the way through. In looking at Table III in the descriptive score for these lots, we find that taints developed in the cheese kept out of the cold rooms for one and two weeks which did not show in the cheese placed at once in the cold room. Further, after these taints had once started to develop, it would certainly appear that the 32-degree temperature served much better to hold them in check than the 40-degree temperature. These points are illustrated and emphasized in many instances in the descriptive score. The influence of the colder temperature seemed about equal on flavor and texture.

The greatest beneficial influence of cold curing is with what would otherwise be poor cheese. Because of this fact Tables III and IV are much more interesting and show more valuable information than the table of average results. Cold curing derives its value chiefly from its effect on what might otherwise be poor cheese rather than from any effect it may have in bettering all cheese.

COLD CURING AND ACID CHEESE.

Perhaps the most interesting feature brought out in all this work is shown in the descriptive scores of lots 7 and 8, low rennet, and lot 9, high rennet. These three lots were allowed to develop too much acid in the process of making, and under ordinary conditions of placing in storage at 2 weeks of age lot 8 would have been a "dead sour." The cheese held in the factory two weeks and placed in the 40-degree room was much deteriorated, while the one that went fresh from the press to

the 32-degree room was very good. It was evident that with this lot of cheese the 32-degree temperature checked the acid much better than the 40-degree temperature. It has been generally believed by dealers that a cheese with too much acid should be kept out of storage as long as convenient, as acid has been supposed to develop more and cause greater injury to the cheese by going early into the cold storage. It would appear from the results with the three lots mentioned that the quicker an acid cheese can be placed in cold storage and the colder the room the better the cheese will be. This is a very important subject with the dealers, for this question of acid is the principal obstacle to the buying of cheese by the dealer as it comes from the hoop. Further investigation of this point is needed, and will be undertaken in the near future.

VARIATIONS IN SCORES OF THE DIFFERENT JUDGES.

Some explanation is needed of the wide variation of scores as given by different judges. The separate scores of each of the three judges are indicated by the initials of their names—B. (Baer), S. (Steinhoff), and W. (White).

As before mentioned, Mr. Baer represented the experimental side, while the other two judges were commercial men. Mr. Baer's scores, therefore, naturally presented a much wider variation than those of the other judges. He took off more for faults. A condition which was not anticipated was found in the tendency of Mr. Steinhoff to mark down the cheese that had been held in the factory for two weeks before curing, because, as he said, it had too high a flavor for the English market. This cheese had barely commenced to develop a good cheese flavor, and had not become sharp in the least. The other two judges were inclined to favor it because of the characteristics which Mr. Steinhoff condemned. The view taken by Mr. Steinhoff was something of a surprise, as it was generally understood that the English people were lovers of cheese with a well-developed, even sharp, flavor. Mr. Steinhoff said that the English demand for milder cheese was growing very rapidly. If this continues, it is only a matter of a very few years until all cheese, if ripened at all, will have to go through the ripening process under conditions of temperature that will entirely suppress flavor development.

As has been stated, the demand for mild cheese has grown by leaps and bounds in this country until it has become possible to dispose of cheese to consumers under two weeks from the time it leaves the press. We do not care to enter into any discussion of the desirability of this popular taste. It would certainly appear to most people who eat cheese because they love it that this tendency is wrong and can have no beneficial effect in the increased use of cheese as a regular part of the diet.

There has been some reason to believe that the consumption of green cheese was due to the fact that such a product was forced on the consumer by the dealers and retailers, so a test was determined on. Arrangements were made with one of the retail dealers in the market at Washington, D. C., to sell three kinds of cheese as an experiment. One lot was under 2 weeks of age and to all appearance had not broken down in the least. Another lot had been ripened from the hoop in a 32-degree temperature and was well broken down but almost without flavor. The third lot had been carried in the factory curing room and then held in a 40-degree room for several months. It was the cheese which Mr. Steinhoff criticised as being too strong for the English market, but which was highly praised by the other judges. These three cheeses were exposed for sale in two different markets, samples from all three lots being placed side by side and customers asked to select. In one stall 8 customers selected the green cheese, 24 selected the mild cold-cured cheese, and 11 selected the cheese with the well-developed flavor. At the other stall 30 selected the green, uncured cheese, 29 selected the mild, well-cured cheese, and 11 selected the cheese with the marked flavor. It would appear from this that the mild cheese, either cured or uncured, was preferred by most buyers.

The writer has no comment to make on this except to repeat that from all indications the time is soon coming when all cheese, if ripened at all, must be ripened at low temperatures; and, further, the sooner it is put into cold storage the better.

RELATION OF GREEN CURD TO CURED CHEESE.

Some interest attaches to the question of how much the quality of the ripened cheese depends upon the quality of the curd during the process of making. It has been usually considered that any undesirable quality likely to be found in the ripened cheese will first appear in the curd sometime during the process of making. In other words, a faulty or tainted curd makes a poor cheese; or, vice versa, a good curd makes a good cheese. Many cheese makers in selecting a cheese for exhibition make the selection by the character of the curd. Lots 12, 14, and 16 (low rennet) and lot 9 (high rennet) in Table I were tainted. The descriptive score shows that lot 12 scored unusually high, lot 14 was about as good, while lot 16 was not a bad cheese. Lot 16 was tainted at the time of scoring, but the other two were not, and had evidently not been influenced by the taint which appeared in the curd. Lot 9 of the high-rennet series turned out to be bitter, but the cheese which went direct into the 32-degree room from the hoop was a very fine cheese, evidently above all criticism.

On the other hand, lots 6 and 13 (low rennet) are marked as very fine curds, as are lots 10, 11, and 12 (high rennet). Lot 6 scored very well, but the others did not score as high as might have been expected.

EFFECT OF EXTRA RENNET.

The advisability of using extra quantities of rennet has not yet been determined. It was found that the cheese broke down faster with high rennet, but this fact has been demonstrated before. Theoretically, where the supply and demand make it necessary to use very young cheese, anything that will hasten the ripening process would be desirable. There is reason to doubt whether this would pay in practice. With regard to the comparative keeping qualities of the high and low rennet cheese, it was stated by the Wisconsin Station that in its experiments the high-rennet cheese deteriorated in quality much quicker than that made with normal rennet. This was not found to be true of the cheese made for the experiments of the Dairy Division. In these experiments it was found, on the other hand, that while the high-rennet cheese broke down in a much shorter period of time than the normal rennet cheese, it held its good qualities fully as long if not longer than the low-rennet cheese. From the scores of the factory-cured cheese it might appear that additional rennet aided the cheese in some way to withstand the warm temperature of the factory curing room.

O

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY.—BULLETIN No. 87.

A. D. MELVIN, CHIEF OF BUREAU.

MARKET MILK INVESTIGATIONS.

II.—THE MILK AND CREAM EXHIBIT AT THE NATIONAL DAIRY SHOW, 1906.

BY

CLARENCE B. LANE, B. S.,

Assistant Chief of Dairy Division, Bureau of Animal Industry.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1906.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., June 16, 1906.

Sir: I have the honor to transmit the accompanying manuscript entitled "The Milk and Cream Exhibit at the National Dairy Show, 1906," by Clarence B. Lane, assistant chief of the Dairy Division of this Bureau, and to recommend its publication as a bulletin in the series of the Bureau.

This milk and cream competition, which was under the direction of the Dairy Division, was a new departure in connection with dairy shows in this country, and the very satisfactory outcome warrants a wide dissemination of the data obtained. The practical results are calculated to be of great educational value to our dairymen and farmers, as they emphasize the importance of sanitary conditions and methods in the production of milk.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

INTRODUCTION.

This bulletin is the second in a series on Market Milk Investigations. The first number, which was not given the general title now adopted for this series, is Bulletin No. 73, "The Bacteria of Pasteurized and Unpasteurized Milk," by L. A. Rogers. The work to be reported in this series will consist of investigations in the problems involved in the handling of market milk from production to consumption. It is the intention to confine the series to original research work by members of the Dairy Division or under its direction.

The present bulletin treats of an experiment in scoring or judging the value of market milk and cream as conducted by Mr. C. B. Lane, Assistant Chief of the Dairy Division, at the National Dairy Show, Chicago, in February, 1906. An attempt was made to determine ways and means of giving a fair and accurate score in this class of dairy products. Butter, cheese, and other products have been for years judged as to their quality in contests and on the market, a numerical score being given to indicate their value. This bulletin treats of the methods used in the Chicago test, with lessons learned from the course of the work.

Much credit should be given to the officers of the National Dairy Show Association and to the Chicago Board of Health for the interest shown and the assistance rendered in making the test a success.

ED. H. WEBSTER,
Chief of Dairy Division.

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ILLUSTRATIONS.

THE MILK AND CREAM EXHIBIT AT THE NATIONAL DAIRY SHOW, 1906.

INTRODUCTORY.

Like many other features of the National Dairy Show held at Chicago, Ill., February 15–24, 1906, the milk and cream exhibit was designed to be educational in its scope and to show some of the possibilities in the handling and keeping of these products. The handling of dairy products is of greater importance to the health of the people consuming them than the production. The most indifferent dairy farmer can produce milk and cream, but it requires knowledge and skill to handle them properly.

For a number of years the National Creamery Buttermakers' Association, as well as State dairy associations, have called for exhibits of butter and cheese at their annual gatherings and offered medals and diplomas for those products receiving the highest scores. It seemed very proper, therefore, that the milk producer should have an opportunity to exhibit his product and have it scored in a similar way. The National Dairy Show at Chicago seemed to offer a most excellent opportunity for such an exhibit, hence the Dairy Division of the Bureau of Animal Industry secured space and called for exhibits of milk and cream from all dairymen throughout the country who could be reached through the medium of the dairy papers and by means of press bulletins.

Much interest was exhibited in the contest from the start and applications for entry came from many sections of the country, the most distant points being Massachusetts on the east, Maryland on the south, and Kansas on the west. Thirteen States were represented in all.

CLASSIFICATION OF THE EXHIBITS.

The exhibits were divided into three classes, as follows:

Class I. Certified milk.—This comprised all milk sold under a guaranty as to its purity, chemical composition, and bacterial content, most milk of this class being produced by expert dairymen in various localities under the direction of the local milk commissions.

Class II. Market milk.—A large percentage of the milk supply of our cities was covered by this class, which of course included all milk that is not sold under any guaranty as to its character.

Class III. Cream.—This was to be sweet cream, unpasteurized and free from preservatives. In fact it was specified that none of the products should be pasteurized. Pasteurized products were not included, principally because the work was more in the nature of an experiment and it was thought best not to include too many classes in the first attempt.

CONDITIONS OF ENTRY.

Separate entry blanks were prepared for each class, but, as they were all quite similar, only one—that for market milk—is presented here.

[National Dairy Show. Milk and cream section, under the direction of the Dairy Division, Bureau of Animal Industry, U. S. Department of Agriculture.]

OFFICIAL ENTRY BLANK.

MARKET MILK (CLASS II).

P. O. address: ——— ———.
Date: ———, *1906.*

E. SUDENDORF, *Chicago, Ill.,*
Secretary, National Dairy Show Association:

Please enter for me 12 quarts of milk to compete for prizes offered by the association at Chicago, Ill., February 15–24, 1906, in accordance with the conditions herein prescribed.

(Signed) ——— ———.

Rules: (1) Exhibitors can make only one entry. This must include 12 quarts of milk in bottles (quarts or pints) placed in a box suitable for shipping. (2) The milk to be the property of the association. (3) Every exhibitor is required to fill out and sign the following certificate:

I, ——— ———, hereby certify that the milk entered in this competition is a fair sample of the product sold by me, that it is free from preservatives, and that it has not been pasteurized or sterilized. I further state that I do not claim or advertise to produce "certified" milk.

(Signed) ——— ———.
(Proprietor) ——— ———.
(Signed in my presence) ——— ———.

The above must be signed by the proprietor, secretary, or manager, and a disinterested party.

JAS. A. WALKER, *President.*
E. SUDENDORF, *Secretary.*

HOW TO COMPETE.

Milk, to compete for prizes, must be sent by express from station nearest the producer, direct to E. Sudendorf, secretary, National Dairy Show Association, care Chicago Cold Storage and Warehouse Company, Sixteenth street and Indiana avenue, Chicago, Ill., and express receipt must accompany entry blank. Express charges on exhibits must be prepaid to destination.

The package should be iced and carefully wrapped, the shipping tag plainly addressed, on outside; also card tacked on box inside the wrapping, plainly giving sender's name and address, so as to avoid mistakes in identifying packages.

In order that the milk entered by the exhibitors may be of the same age when scored, it is hereby specified that it shall be drawn from the cows February 12 and shipped by express as soon thereafter as possible.

The secretary or his representative will be on hand to take charge of milk on its arrival and will see that it is properly cared for.

It is desirable that the package be plainly marked in some way giving the name of the exhibitor, and that the bottles, caps, etc., be such as are used in the regular trade, thus giving an individuality to each exhibit. It is also desired, if possible, that a photograph of either the interior or exterior of your dairy barn or dairy house accompany the application for use in the exhibit.

Only these official entry blanks furnished by the secretary will be accepted.

QUESTIONS TO BE ANSWERED BY EXHIBITORS.

1. Give date and hour this milk was drawn from the cow: ———.
2. Give date and hour this milk was delivered to the express company: ———.
3. Does this milk fairly represent the average product of your herd in quality and cleanliness? ———.
4. How was the milk treated from the time it was drawn from the cow until shipped? ———.

Remarks: ———.

SCORING THE MILK AND CREAM.

The idea of scoring milk and cream on a basis similar to that used for butter, and having score cards giving a certain number of points for flavor, composition, and bacterial content, is entirely new, but this plan was carried out in the present instance with most satisfactory results. In fact, much less difficulty was experienced by the judges in deciding upon the various points than was anticipated. As already stated, all the milk and cream entered in this contest was produced on February 12 and was packed in ice and shipped to a cold-storage house in Chicago. The scoring was done February 15, when the product was three days old.

JUDGES AND EXPERTS.

It was planned at the outset to give the products exhibited the most careful and rigid examination possible on all points, so that the final results would be beyond question. The judges were C. B. Lane, assistant chief of the Dairy Division; W. A. Stocking, jr., bacteriologist, Storrs Experiment Station, and Ivan C. Weld, instructor in dairying, New Hampshire College. In addition to the judges, two experts from the Dairy Division were employed to make tests, namely, C. E. Gray, chemist, and L. A. Rogers, bacteriologist.

SCORE CARDS.

The score cards used in each class are presented herewith. While some minor changes would probably be made if the work were repeated, in general it may be said that they were satisfactory to all concerned.

1883—No. 87—06——2

[National Dairy Show, Chicago, Ill., February 15-24, 1906.]

Milk Judging—Class I (Certified Milk).

Under the direction of the Dairy Division, Bureau of Animal Industry, U. S. Department of Agriculture.

Score for sample marked: ....

NUMERICAL SCORE.

Perfect, 100 points.	Flavor, 40 points.	Chemical qualities, 20 points.	Keeping qualities, 30 points.	General condition and appearance of package and contents, 10 points.
Score............	....	....	....	....

Date: ———, 1906. Initials of Judge: ———.

DESCRIPTIVE SCORE.
(Check as found below.)

Flavor.	Chemical qualities.	Keeping qualities.	General condition and appearance of package and contents.
Perfect.	Perfect.	Perfect.	Perfect.
Bitter.	Fat below amount guaranteed.	Bacteria exceed guarantee.	Sediment.
Weedy.	Total solids below amount guaranteed.	Objectionable bacteria.	Unattractive.
Garlic.		Excessive acid.	
Silage.		Sour.	
Cowy.			

[National Dairy Show, Chicago, Ill., February 15-24, 1906.]

Milk Judging—Class II (Market Milk).

Under the direction of the Dairy Division, Bureau of Animal Industry, U. S. Department of Agriculture.

Score for sample marked: ....

NUMERICAL SCORE.

Perfect, 100 points.	Flavor, 40 points.	Chemical qualities, 25 points.	Keeping qualities, 25 points.	General condition and appearance of package and contents, 10 points.
Score............	....	....	....	....

Date: ———, 1906. Initials of Judge: ———.

DESCRIPTIVE SCORE.
(Check as found below.)

Flavor.	Chemical qualities.	Keeping qualities.	General condition and appearance of package and contents.
Perfect.	Perfect.	Perfect.	Perfect.
Bitter.	Fat below 3.25 per cent.	Bacteria exceed 100,000 per c. c.	Sediment.
Weedy.	Total solids below 12 per cent.	Objectionable bacteria.	Unattractive.
Garlic.		Excessive acid.	
Silage.		Sour.	
Cowy.			

[National Dairy Show, Chicago, Ill., February 15-24, 1906.]

CREAM JUDGING—CLASS III.

Under the direction of the Dairy Division, Bureau of Animal Industry, U. S. Department of Agriculture.

Score for sample marked: ....

NUMERICAL SCORE.

Perfect, 100 points.	Flavor, 40 points.	Chemical qualities, 20 points.	Keeping qualities, 25 points.	General condition and appearance of package and contents, 15 points.
Score............	....	....	....	....

Date: ———, 1906. Initials of judge: ———.

DESCRIPTIVE SCORE.

(Check as found below.)

Flavor.	Chemical qualities.	Keeping qualities.	General condition and appearance of package and contents.
Perfect.	Perfect.	Perfect.	Perfect.
Bad odor.	Wide variation from guaranteed percentage of fat.	Excessive number of bacteria.	Frothy.
Bitter.	Fat.	Objectionable bacteria.	Lumpy.
Weedy.	Solids not fat.	Excessive acid.	Sediment.
Garlic.	Total solids.	Sour.	Unattractive
Silage.			
Cowy.			

TESTS FOR FLAVOR.

Flavor was given the most points on the score card in all three classes for the reason that it was considered the most important. Unpalatable milk or cream is of practically no value as an article of food; on the other hand, if these products contain a low percentage of fat or solids not fat or an excessive number of bacteria and still have a good flavor, they may be utilized, and, in fact, more or less milk and cream of this character is used. Hence we see that flavor is of the first importance.

Before making the tests the samples of milk were heated in a water bath to a temperature of about 100° F. This heating seemed to bring out objectionable flavors in a more marked degree than when the milk was cold, although tests were made of both the cold and warm milk. Tests for flavor in the cream samples were made in a similar manner. If one has never collected a promiscuous lot of samples and made tests of this character, he will be surprised how easily off-flavors may be detected and how much the quality of the flavor, so to speak, varies. Some of the samples tested seemed to

be almost entirely lacking in flavor, while others had a rich, pleasant flavor and aroma.

TESTS FOR CHEMICAL QUALITIES.

The following remarks are by C. E. Gray, who made the chemical tests:

The acidity of the milk and cream was determined by "Mann's test," the butter fat by the Babcock method, and solids not fat by the lactometer. In addition to these analyses all samples were tested for formaldehyde by Hehner's method. None of this preservative could be detected in any of the samples. All samples were tested for pasteurization by Stock's method. From this test it could not be determined conclusively that any of the samples had been pasteurized.

TESTS FOR KEEPING QUALITIES.

L. A. Rogers, who performed the bacteriological work, remarks as follows:

All plates were made with ordinary 2 per cent lactose gelatin and with dilutions varying from $\frac{1}{10}$ c. c. to $\frac{1}{100000}$ c. c. The counts were made after five days, excepting when the rapid growth of liquifying colonies made an earlier count necessary. In some cases it was evident from the acidity of the milk that the colonies of the lactic-acid bacteria had not developed at the time the bacteria on the plates were counted.

It is unsafe to generalize from the limited data obtained in this manner. However, many of the producers of these milks demonstrated that milk with a low bacterial content can be secured without the expensive apparatus usually found in the so-called sanitary dairies. Those who understand and observe the fundamental rules of cleanliness in the stable, where the great contamination of milk occurs, have little difficulty in producing milk with good keeping qualities.

APPEARANCE OF PACKAGES AND CONTENTS.

It is of interest to note the different styles of shipping cases in which the exhibits were sent (see pl. 1, fig. 1). Some were very neat (see pl. 1, fig. 2), and this goes a good way in selling milk. Many of them were made entirely of wood, others had a galvanized-iron case inside of a wooden box. All of the samples were heavily iced.

While only a few points were allowed on the score card for the appearance of the package and contents, this phase of the scoring is considered of sufficient importance to call for special attention. There is no excuse for the presence of dirt or sediment of any kind in milk or cream; it is an indication that it comes from an unclean dairy. Wherever such was found by the judges, six points were deducted, and several bottles were always examined to make sure that this criticism could justly be made on the whole shipment. Aside from sediment, the general appearance and neatness of the package was considered. Sometimes the caps fitted very poorly and in one or two instances tin tops were used, the latter not being desirable from a sanitary standpoint. In the case of the certified milk a number of styles of caps, coverings, and methods of sealing were presented, some of which were very attractive.

Fig. 1.—Some of the Shipping Cases Containing Samples of Milk and Cream.

Fig. 2.—A Good Shipping Case.

FIG. 1.—STYLES OF BOTTLES IN CLASS I—CERTIFIED MILK.

FIG. 2.—STYLES OF BOTTLES IN CLASS II—MARKET MILK.

(See description in text, page 13.)

A few samples of bottles and coverings are shown in plate 2, a brief description of which is as follows: Counting from left to right of figure 1—certified milk—the top of the first bottle has an outside covering of thin paper fastened with an elastic band; on this covering are stamped the words "Certified milk" and the name of the dairy. This covering prevents dust from reaching the inner cap; the latter, which fits tightly into the top of the bottle, is the ordinary paper pulp cap commonly used for milk bottles. The tops of the second and third bottles are neatly covered with tin foil, under which were ordinary paper caps covered with about one-eighth inch of paraffin. The tin foil and paraffin make the finish more expensive, but they are more satisfactory to the customer, and, altogether, these two bottles present the most attractive appearance. In addition to the above precautions the second bottle is fastened with a wire and lead seal. The fourth and fifth bottles are also covered with tin foil, but are not as attractive as the two just described, for the reason that the foil extends down too far on the bottle and looks ragged. These bottles have no paraffin under the foil, simply a plain cap. The last bottle to the right has a piece of thin rubber cloth fastened over the top with an elastic band; this keeps out all water and dust, but it is not very attractive. It will be noted that while the six bottles all hold the same amount of milk, there is quite a difference in their height, some having a short neck and others a tall slim neck, which makes the cream appear to have greater volume.

Turning to figure 2—market milk—we have quite a contrast in the style of bottles presented. Counting from the left, the first, third, and fourth are ordinary types of market milk bottles having ordinary caps. In the case of the first, however, about one-eighth of an inch of paraffin is filled in over the cap, making it air-tight and dust proof. The second bottle differs from the others in having the neck marked off in rings, indicating the number of ounces of cream on the top of the bottle. The fifth and sixth bottles have tin tops in addition to paper caps. This style of top is not considered sanitary and is gradually disappearing from the milk trade.

SCORES.

The numerical and descriptive scores are given in the following tables:

Numerical scores of the exhibits of certified milk, market milk, and cream.

CLASS I—CERTIFIED MILK.

Sample No.	Flavor (perfect 40 points).	Chemical qualities (perfect 20 points).	Keeping qualities (perfect 30 points).	General condition and appearance of package and contents (perfect 10 points).	Total score.
101	36	20	30	10	96
102	35	20	30	10	95
103	37	20	[a] [b] 20	10	87
104	38	20	30	10	98
105	37	20	30	10	97
106	35	20	30	10	95
107	35½	20	30	10	95½
115 [c]	...	...	...	...	...

CLASS II—MARKET MILK.

Sample No.	Flavor (perfect 40 points).	Chemical qualities (perfect 25 points).	Keeping qualities (perfect 25 points).	General condition and appearance of package and contents (perfect 10 points).	Total score.
201	35	25	25	10	95
202	34	25	[d] 23	10	92
203	35	[e] [f] 17	[d] 23	[g] 9½	84½
204	33	25	25	10	93
205	30	25	[d] 23	10	88
206	33½	25	25	10	93½
207	34	25	25	10	94
208	30	25	25	10	90
209	33	25	25	10	93
210	32	25	25	10	92
211	30	25	25	[h] 4	85
212	37	[e] [f] 19	[a] [b] 17	10	83
213	36	25	25	10	96
214	33	25	25	[h] 4	87
215	35	25	25	[h] 4	89
216	30	25	[a] [b] 8	[g] 8	71
217	30	25	25	10	90
218	32	25	[a] [b] 19	10	86
219	35	25	24	3	87
220	35	25	25	10	95
221 [c]	...	...	...	...	...
222	35	25	[a] 24	10	94
223	36	25	[b] 24½	10	95½

[a] Excessive bacteria.
[b] Objectionable bacteria.
[c] Barred from competition.
[d] Excessive acid.
[e] Fat below standard.
[f] Solids below standard.
[g] Imperfect package.
[h] Sediment.

Numerical scores of the exhibits of certified milk, market milk, and cream—Continued.

CLASS III—CREAM.

Sample No.	Flavor (perfect 40 points).	Chemical qualities (perfect 20 points).	Keeping qualities (perfect 25 points).	General condition and appearance of package and contents (perfect 15 points).	Total score.
301	36	20	25	15	96
302	33	20	[a] 23	[b] 10	86
303	36	[c] 19	25	15	95
304	35	20	25	15	95
305	37	20	[d] [e] 20	[f] 14	91
306 [g]					
307	34	20	[d] 23	[f] 14½	91½
308	37	20	25	15	97
309	37½	20	[e] 24	15	96½
310	38	20	[d] [e] 22	15	95
311	36½	20	25	[f] 14	95½
314	37	20	25	[f] 14	96
315	38	20	25	15	98
316	33	20	25	15	93
317	32	20	25	[f] [h] 9	86

[a] Excessive acid.
[b] Frothy and lumpy.
[c] Fat below standard.
[d] Excessive bacteria.
[e] Objectionable bacteria.
[f] Imperfect package.
[g] Barred from competition.
[h] Sediment.

Descriptive scores of the exhibits of certified milk, market milk, and cream.

CLASS I—CERTIFIED MILK.

Sample No.	Flavor.	Specific gravity.	Fat.	Solids not fat.	Total solids.	Acidity.	Total bacteria per cubic centimeter.	Liquefying bacteria per cubic centimeter.	Remarks.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*			
101	Good	1.0313	5.0	8.84	13.84	0.189	200	30	Slow liquefiers.
102	do	1.0303	5.3	8.64	13.94	.175	850	0	
103	Excellent	1.0324	4.1	8.93	13.03	.185	51,000	1,200	Potato bacillus.
104	do	1.0324	4.2	8.95	13.15	.198	2,500	500	Slow liquefiers.
105	do	1.0313	4.7	8.78	13.48	.193	120	30	Do.
106	Good	1.0313	3.8	8.60	12.40	.189	0	0	
107	Excellent	1.0313	4.7	8.78	13.48	.171	260	20	Potato bacillus.
115 [a]									
	Average		4.5	8.79	13.33	.186	7,847	254	

[a] Barred from competition.

Descriptive scores of the exhibits of certified milk, market milk, and cream—Continued.

CLASS II—MARKET MILK.

Sample No.	Flavor.	Specific gravity.	Fat.	Solids not fat.	Total solids.	Acidity.	Total bacteria per cubic centimeter.	Liquefying bacteria per cubic centimeter.	Remarks.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*			
201...	Excellent...	1.0324	5.8	9.28	15.09	0.207	35,000	5,000	
202...	Good.......	1.0345	5.8	9.56	15.36	.234	8,800	700	Liquefiers, various kinds.
203...	Excellent...	1.0355	2.6	9.38	11.98	.237	2,900	100	Slow liquefiers.
204...	Good.......	1.0313	4.4	8.72	13.12	.196	900	0	
205...	Strong......	1.0324	6.0	9.33	15.33	.258	23,600	300	
206...	Good.......	1.0303	5.5	8.67	14.17	.175	2,400	1,000	Do.
207...	.....do......	1.0318	5.0	9.22	14.22	.201	400	100	
208...	Unpalatable	1.0318	3.6	8.93	12.53	.192	14,500	0	Spreading liquefiers.
209...	Unpleasant.	1.0328	4.4	9.10	13.50	.199	3,600	200	
210...	.....do......	1.0303	4.6	9.14	13.74	.171	3,300	500	Large spreading liquefiers.
211...	Unpalatable	1.0318	5.0	8.96	13.96	.205	19,000	4,000	
212...	Excellent...	1.0303	3.2	8.22	11.42	.176	295,000	109,000	Liquefiers spreading, growth diffused.
213...	Fine........	1.0308	4.6	8.68	13.28	.198	6,000	600	
214...	Unpalatable	1.0303	4.2	8.42	12.62	.180	13,800	2,600	Liquefiers large, spreading.
215...	Good.......	1.0313	3.6	8.55	12.15	.172	6,000	2,000	Slow liquefiers.
216...	Unpalatable	1.0324	4.2	8.95	13.15	.225	21,000,000	710,000	
217...	.....do......	1.0334	3.8	9.12	12.92	.221	900	0	
218...	Unpleasant.	1.0313	7.1	9.28	16.38	.183	241,000	72,000	Spreading liquefiers.
219...	Good.......	1.0329	3.4	8.92	12.22	.189	57,000	10,000	Liquefiers, proteus like.
220...	.....do......	1.0318	4.2	8.55	12.75	.194	13,600	9,500	Liquefiers, small colonies.
221 [a]...	....	....	....	....	....	....	....	....	
222...	Good.......	1.0335	4.0	9.19	13.19	.198	113,000	14,000	Liquefiers, spreading.
223...	Excellent...	1.0340	4.4	9.4	13.80	.214	41,000	8,900	Small colonies liquefiers.
	Average.	....	4.5	8.98	13.49	.200	995,182	43,204	

CLASS III—CREAM.

Sample No.	Flavor.	Specific gravity.	Fat.	Solids not fat.	Total solids.	Acidity.	Total bacteria per cubic centimeter.	Liquefying bacteria per cubic centimeter.	Remarks.
301...	Excellent...	....	34.0	....	....	0.232	4,000	200	Slow liquefiers.
302...	Bad........	....	44.0	....	....	.270	1,200	500	Potato bacillus.
303...	Excellent...	....	17.0	....	....	.218	12,000	200	Slow liquefiers.
304...	.....do......	....	36.0	....	....	.187	88,000	4,000	Potato bacillus.
305...	.....do......	....	34.0	....	....	.217	2,810,000	43,000	Spreading liquefiers.
306 [a]...	....	....	....	....	....	....	....	....	
307...	Good.......	....	29.0	....	....	.241	426,000	600	Do.
308...	Excellent...	....	26.0	....	....	.202	16,700	2,100	Do.
309...	.....do......	....	31.0	....	....	.171	98,000	25,000	Do.
310...	.....do......	....	31.0	....	....	.171	256,000	76,000	Liquefiers spreading, various kinds.
311...	Good.......	....	25.0	....	....	.176	0	0	Liquefiers spreading.
314...	Excellent...	....	36.0	....	....	.180	2,300	100	Potato bacillus.
315...	.....do......	....	27.0	....	....	.198	46,000	8,600	Liquefiers slow, yellow color.
316...	Bitter......	....	34.0	....	....	.203	166,000	14,000	Liquefiers spreading.
317...	Cowy.......	....	([b])	....	....	.207	104,000	7,000	Liquefiers spreading, growth diffused.
	Average.	....	31.0	....	....	.205	287,871	12,950	

[a] Barred from competition.

[b] Fat per cent not determined.

THE AWARDS IN CLASS I—CERTIFIED MILK.

There were eight entries in this class, and none of them had a disagreeable flavor, but there was a great difference in the quality or pleasantness of the flavor. The chemical qualities of the milk received most careful attention, and the percentage of butter fat ranged from 3.8 to 5.3, averaging 4.5. The percentage of total solids ranged from 12.40 to 13.94, and averaged 13.33. The variation was, therefore, within comparatively narrow limits, which of course would naturally be expected in milk of this class. The number of bacteria in the certified milk samples ranged from 0 to 51,000 per cubic centimeter. The number of putrefactive and undesirable bacteria was very small in most cases. The percentage of acidity varied from 0.171 to 0.198, and averaged 0.186. It should be remembered that all samples were 3 days old when tested. The scores varied from 87 to 98, and averaged 94.8. There was no sediment found in any of these samples.

The medals and diplomas in this class were awarded as follows:

Number of sample and name of exhibitor.	State.	Score.	Award.
104. S. M. Shoemaker	Maryland	98	Gold medal.
105. Frank J. Carr	New York	97	Silver medal.
101. Wawa Dairy Farm	Pennsylvania	96	Diploma.
107. Towar's Wayne County Creamery Co	Michigan	95½	Do.
102. St. Louis Dairy Co	Missouri	95	Do.
106. Woodend Farm Co	Minnesota	95	Do.

One entry not included above failed to reach the diploma mark (95), and one was barred from competition.

CONDITIONS UNDER WHICH THE CERTIFIED MILK WINNING THE GOLD MEDAL WAS PRODUCED.[a]

The building in which the cows were stabled was a single story, with concrete and glass sides, plastered ceiling, concrete floors, individual watering device, and a modern system of ventilation. (See pl. 3.) The cows were principally grade Shorthorns, with a few grade Holsteins. Previous to milking the fore milk was drawn into a small cup at the side of the milk pail. The pail had a small aperture over which was drawn a sterile cheese cloth, a fresh cloth being used for each cow. The milk was promptly removed from the barn and run over a cooler and bottled as quickly as possible. The feeds used were those ordinarily approved for cattle, cotton-seed meal and silage being used moderately.

DESCRIPTION OF THE DAIRY PRODUCING THE CERTIFIED MILK WHICH WON THE SILVER MEDAL.

The cows are kept in a basement barn with concrete floor. The stable is well lighted and ventilated. The herd of 200 cows is composed of Brown Swiss, Jerseys, and a few Holstein-Friesians.

[a] The same exhibitor also won the silver medal in the cream contest.

The dairy building is all concrete, built upon the most approved plans, and equipped with modern dairy utensils. After milking, the milk is simply run over a cooler, bottled, and iced.

THE AWARDS IN CLASS II—MARKET MILK.

There were 23 entries in this class, and all of the milk was sound and sweet when tested. A great variety of flavors were found in the samples exhibited in this class; one had a pronounced silage odor, two or three had a suggestion of a cowy odor, etc. The percentage of butter fat in the various samples ranged from 2.6 to 7.1, and averaged 4.5. All but two samples passed the standard of 3.25 per cent which was used in this test. The total solids ranged from 11.42 to 16.38 per cent, and averaged 13.49, all but two passing the standard of 12 per cent. The acidity ranged from 0.171 to 0.258 per cent, and averaged 0.200; three were above the standard of 0.225 per cent. The total bacteria ranged from 400 to 21,000,000 per cubic centimeter; leaving out the highest count (21,000,000), the average was 39,273. The liquefying bacteria ranged from 0 to 710,000, and averaged 43,204. The total score ranged from 71 to 96, and averaged 89.7.

The following were awarded medals or diplomas in this class:

Number of sample and name of exhibitor.	State.	Score.	Award.
213. Wyatt & Son	Wisconsin	96	Gold medal.
223. S. Edwin Thornton	Maryland	95½	Silver medal.
201. N. N. Rose	New York	95	Diploma.
220. Storrs Experiment Station	Connecticut	95	Do.
222. H. P. Hood & Sons	Massachusetts	94	Do.
207. Mrs. N. E. Parrish	Kansas	94	Do.
206. C. E. Hill	Illinois	93½	Do.
209. S. M. Shoemaker	Maryland	93	Do.
204. Wieland Dairy Co	Illinois	93	Do.
202. L. P. Bailey	Ohio	92	Do.
210. J. Gilbert Hickcox	Wisconsin	92	Do.
217. A. E. Thompson	Illinois	90	Do.
208. Union Dairy Co	do	90	Do.

Ten in this class, not included above, failed to reach the diploma mark (90).

CONDITIONS UNDER WHICH THE MARKET MILK RECEIVING THE GOLD MEDAL WAS PRODUCED.

The herd consists of choice purebred and grade Jerseys, numbering about 30 milking cows. It is the practice of the owner to raise heifer calves from the best cows. The barn is well lighted and ventilated, the floors are of cement, and the walls and ceiling are kept thoroughly whitewashed. The manure from the stables is hauled direct to the field.

The feed used in this dairy consists of corn silage (well eared), shredded corn stover, and mixed hay for roughage, the grain part consisting of wheat bran and middlings and buckwheat middlings, besides the corn in the silage. Care is taken during milking to have as little dust as possible in the barn. The cows are kept thoroughly clean.

INTERIOR OF STABLE WHERE CERTIFIED MILK WINNING GOLD MEDAL WAS PRODUCED.

FIG. 1.—INTERIOR OF DAIRY HOUSE WHERE MARKET MILK RECEIVING GOLD MEDAL WAS HANDLED.

FIG. 2.—SOME OF THE COWS WHICH PRODUCED MARKET MILK RECEIVING GOLD MEDAL.

The milk from each cow is weighed after milking, and as soon as a small can is filled it is taken to a separate building used only for handling milk. Here the milk is strained through a wire strainer and three cloth strainers and stored in cold water until bottled. After bottling, the milk is placed in cases and packed in ice ready for delivery. All dairy utensils are rinsed, washed, scalded with boiling water, and drained. The herd is tuberculin tested and great care is exercised to keep it healthy.

The milk retails at 6 cents per quart throughout the year in a small town of 3,000 inhabitants. The owners take much pride in producing clean milk free from dangerous germs.

DESCRIPTION OF THE DAIRY WHICH PRODUCED THE MARKET MILK WINNING THE SILVER MEDAL.

The barn is a frame structure of ordinary type. The herd of 28 cows is of mixed breeding, and includes Jersey, Holstein, and Shorthorn grades. The cows are fed a well-balanced ration the year round. When the milk was produced for the contest the ration consisted of millet hay and cut corn stover, supplemented with corn and cob meal, dried brewers' grains, and molasses feed. The milk was produced and handled in a cleanly manner, cooled and aerated immediately after being drawn, and stored in spring water.

THE AWARDS IN CLASS III—CREAM.

The exhibits of this product were of a very fine character, considering that they were three days old when scored and that some of them had been shipped from a distance of over a thousand miles. The percentage of fat in the various cream samples ranged from 17 to 44, the acidity from 0.171 to 0.270. One only was found to be above the acidity standard of 0.25 per cent. The total bacteria ranged from 0 to 2,810,000. The number of liquefying bacteria ranged from 0 to 76,000. The total scores ranged from 86 to 98, and averaged 93.6.

The awards in the cream contest were as follows:

Number of sample and name of exhibitor.	State.	Score.	Award.
315. Storrs Experiment Station	Connecticut	98	Special gold medal.
308. Union Dairy Co.	Illinois	97	Gold medal.
309. S. M. Shoemaker	Maryland	96½	Silver medal.
314. Frank E. Headley	Missouri	96	Diploma.
301. M. N. Ross	New York	96	Do.
311. Cott Barnett	Indiana	95½	Do.
303. L. P. Bailey	Ohio	95	Do.
304. Grace G. Durand	Illinois	95	Do.
310. J. Gilbert Hickcox	Wisconsin	95	Do.
316. Towar's Wayne County Creamery	Michigan	93	Do.
307. R. F. Shannon	Pennsylvania	91½	Do.
305. U. A. Towers	Wisconsin	91	Do.

Three in this class, not included above, failed to reach the diploma mark (90).

CONDITIONS UNDER WHICH THE CREAM RECEIVING THE SPECIAL GOLD MEDAL WAS PRODUCED.

The milk from which the cream was taken was the mixed milk of a herd made up of purebred Jerseys, Guernseys, Ayrshires, and Holstein-Friesians.

The grain fed consisted of a mixture of 400 pounds wheat bran, 100 pounds cotton-seed meal, and 100 pounds corn meal, 6 to 8 pounds of this mixture being fed to each cow. For roughage each cow received 40 pounds of silage and 5 pounds of hay. Previous to milking, the udders were wiped with a damp cloth and the milk was drawn into covered milk pails. After being drawn, the milk was taken at once to the dairy, separated by means of a centrifugal separator, and immediately cooled and iced.

LESSONS FROM THE CONTEST.

THE KEEPING QUALITIES OF SANITARY MILK.

As stated at the outset, the object of this contest was wholly educational. It was desired to show that milk and cream produced under sanitary conditions could be shipped long distances and held for several weeks without any other means of preservation than cleanliness and cold. The results were most gratifying, and some of the samples remained perfectly sweet after being shipped a thousand miles across the country, put in storage at a temperature of about 32° F. for two weeks, and then reshipped a distance of 900 miles to Washington, D. C., where they were stored in an ordinary ice box for several weeks longer, some of the certified milk samples being still sweet after five weeks. A part of a box of cream entered in this contest was placed in cold storage in Chicago at a temperature of 33° F. and remained sweet and palatable for a period of seven weeks.

SUPERIORITY OF CERTIFIED OVER MARKET MILK.

The so-called certified milk entered in this contest was quite superior to the market milk, the total scores averaging 94.8 and 89.7, respectively. This result goes to show that certified milk is a superior article, and is actually worth more when we consider its better flavor and keeping quality and freedom from objectionable bacteria, and, further, the fact that the richness of the milk is guaranteed. It is apparent that the producer of certified milk must be a thoroughly capable man. He must understand matters pertaining to the healthfulness of cows, the effect of disease or any inflammation or unusual condition of the cow upon the milk, also the composition and effect of the various feeding stuffs on the cows, the effect of overfeeding, and unusual disturbances which affect the quality or flow of the milk; he must have some knowledge of bac-

teria and know the importance of sterilizing utensils, which are sources of bacterial contamination. He must appreciate the fact that injudicious feeding of turnips, garlic, ragweed, and unsound silage will produce undesirable flavors in milk, and must know how to guard against them. The work of the producer of certified milk is often too little appreciated by those who require such milk for the sick room, infants, etc. They should rejoice in the fact that by paying a little higher price than that charged for ordinary milk a product can be secured that is guaranteed to be rich, pure, clean, wholesome, and produced from healthy cows.

It may be said concerning the market milk exhibited that a large percentage of the samples remained sweet for a week in the exhibit case, the temperature of which was about 50° F. While these samples probably represented a very much higher quality of milk than that ordinarily supplied to our cities, it may be said to be demonstrated that market milk will keep for several days if handled with reasonable care and held at a temperature below 50° F.

While no definite percentage of fat was specified for market milk except that it should be above the standard of 3.25, it is of interest to note the wide variations shown in the 23 samples exhibited, namely, 2.6 to 7.1, the average being 4.5. It is known that such wide variations are not uncommon in the milk supplied to many of our cities.

It may be stated that these wide variations occur not only in the milk supplied by different dealers, but in the milk from the same dealer from day to day, particularly where the "dippage" system is practiced. These variations may be due to not properly mixing the milk from the different cows, or failing to mix the milk in the can before dipping it out. This results in dissatisfaction on the part of the consumers, for the reason that they do not want cream delivered to them one day and a product approaching skim milk the next. This question of uniformity is one of great importance to both producer and consumer.

SANITARY METHODS MORE IMPORTANT THAN BREED OF COWS.

The fact is also of interest that both the milk and the cream which won the medals in the contest were produced from herds that were largely of mixed breeding. This indicates that the sanitary conditions under which milk is produced and the method of handling it are of more importance than the fact that the animals are purebred or that they are of some particular breed.

O

CONTROL AND ERADICATION OF CONTAGIOUS DISEASES.

Inspectors in charge of districts.

Dr. R. A. Ramsay, room 320 Quincy Building, Denver, Colo., in general charge of eradication of scabies of sheep and cattle in the West.
Albuquerque, N. Mex.—Dr. Louis Metsker, room 22 N. T. Armijo Building.
Denver, Colo.—Dr. Lowell Clarke, room 320 Quincy Building.
Fargo, N. Dak.—Dr. R. H. Treacy.
Kansas City, Kans.—Albert Dean, room 328 Live Stock Exchange.
Salt Lake City, Utah.—George S. Hickox, room 21 Eagle Block.

INSPECTION OF LIVE STOCK FOR EXPORT.

Inspectors in charge.

Baltimore, Md.—Dr. H. A. Hedrick, 215 St. Paul street.
New York, N. Y.—Dr. W. H. Rose, 18 Broadway.
Norfolk, Va.—Dr. G. C. Faville, P. O. box 796.
Philadelphia, Pa.—Dr. C. A. Schaufler, 134 South Second street.
Portland, Me.—Dr. F. W. Huntington, U. S. customs office, Grand Trunk R. R. wharf.

INSPECTION AND QUARANTINE OF IMPORTED ANIMALS.

Quarantine stations.

Athenia, N. J. (for the port of New York).—Dr. George W. Pope, superintendent.
Halethorp, Md. (for the port of Baltimore).—William H. Wade, superintendent.
Littleton, Mass. (for the port of Boston).—Dr. J. F. Ryder, inspector in charge, 141 Milk street, Boston, Mass.

Inspectors on the Canadian border.

Calais, Me.—Dr. H. T. Potter.
Carthage, N. Y.—Dr. W. S. Corlis.
Detroit, Mich.—Dr. L. K. Green, care Hammond, Standish & Co.
Fort Fairfield, Me.—Dr. F. M. Perry.
Malone, N. Y.—Dr. H. D. Mayne.
Newport, Vt.—Dr. G. W. Ward.
Ogdensburg, N. Y.—Dr. Charles Cowie.
Orono, Me.—Dr. F. L. Russell.
Port Huron, Mich.—Dr. David Cumming, 912 Lapeer avenue.
St. Albans, Vt.—Dr. C. L. Morin.
Sault Ste. Marie, Mich.—Dr. J. F. Deadman.

Inspectors on the Mexican border.

El Paso, Tex.—Dr. Thomas A. Bray.
San Antonio, Tex.—Dr. Joseph W. Parker.
San Diego, Cal.—Dr. Robert Darling, care Charles S. Hardy.

VETERINARY INSPECTORS STATIONED ABROAD.

Dr. W. H. Wray, 34 Streatham Hill, London, S. W., England, in charge for Great Britain and Ireland.
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Dr. V. A. Norgaard, Honolulu, Hawaii.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY.—BULLETIN No. 88.

A. D. MELVIN, CHIEF OF BUREAU.

THE TUBERCULIN TEST OF HOGS

AND

SOME METHODS OF THEIR INFECTION WITH TUBERCULOSIS.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., June 20, 1906.

Sir: I have the honor to transmit herewith, and to recommend for publication as a bulletin of this Bureau, a manuscript on "The Tuberculin Test of Hogs and Some Methods of their Infection with Tuberculosis," by Drs. E. C. Schroeder and John R. Mohler, of this Bureau.

This article reports two lines of experiments, from which the authors conclude, among other things, that with proper precautions to keep the animals quiet the tuberculin test may be practically applied to hogs with as reliable results as with cattle, and that hogs readily contract tuberculosis through the ingestion of infected food. The experiments indicate that in the common practice of feeding hogs after cattle there is great danger, if the cattle are affected with tuberculosis, of the disease being communicated to the hogs.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

THE TUBERCULIN TEST OF HOGS AND SOME METHODS OF THEIR INFECTION WITH TUBERCULOSIS.

INTRODUCTORY.

The increased frequency with which the occurrence of tuberculosis among hogs is being reported calls attention, in addition to the other questions it presents, to the unsatisfactory status of our knowledge relative to the tuberculin test in its application to hogs. The series of experiments recorded in this article were made, at the suggestion and by direction of Dr. A. D. Melvin, Chief of the Bureau of Animal Industry, in order to obtain better information on this subject, and to determine conclusively, if possible, in what measure dependence can be placed on tuberculin used as a diagnostic agent for tuberculosis in hogs; also to gain information as to the manner in which hogs contract tuberculosis in their natural environment.

HOGS USED IN THE EXPERIMENTS.

The hogs used may be divided into five groups:

I. Twelve hogs infected with tuberculosis by feeding them partially with milk to which virulent tubercle bacilli had been added.

II. Four hogs that were fed behind cattle affected with natural tuberculosis.

III. Four hogs that were fed behind cattle affected with tuberculosis by adding tubercle bacilli daily to their drinking water. (Very little water, other than that to which tubercle bacilli had been added, was received by the cattle during the time the hogs of this group were behind them.)

IV. Twelve hogs infected with tuberculosis through subcutaneous inoculation with virulent tubercle bacilli.

V. Twenty-six supposedly normal, healthy hogs.

All these hogs were used in the tuberculin tests, and the hogs of Groups I, II, and III were also used in the experiments with methods of contracting tuberculosis.

All the hogs included in Groups I, II, III, and IV, and one hog of Group V were killed and autopsies held after the conclusion of the tuberculin tests. This leaves 25 hogs of Group V that are still alive

and well. The latter were received from a source from which about 2,000 hogs have been examined postmortem during the last ten years, and among which only two cases of tuberculosis (0.1 per cent) were discovered. Hence it is not regarded as necessary that the 25 animals, not one of which showed the least tendency to react to tuberculin, should be killed and examined postmortem to show more conclusively that they are free from tuberculosis. The probability for each one of the hogs that it is affected, without taking the absence of a tuberculin reaction into consideration, is 1 chance per 1,000 (0.1 per cent), and consequently the chance that a single case of tuberculosis exists among the entire 25 hogs is 25 chances per 1,000, or 1 chance in 40. The one hog of Group V that was killed and examined postmortem showed peculiarities of temperature during the tuberculin test that made an autopsy desirable.

TUBERCULIN AS A DIAGNOSTIC AGENT FOR TUBERCULOSIS IN HOGS.

VARIABILITY OF TEMPERATURE OF HOGS.

Before entering upon a discussion of the tuberculin tests it is desirable to say a few words about the temperature of hogs generally. The normal variations that occur in individual hogs are very great, so great, indeed, within short periods of time, and from apparently inadequate and frequently undiscoverable causes, that it seems at first that they are wholly incompatible with the successful application of a test which depends, for the information that can be derived from it, on a reasonable constancy of the temperature in the absence, and an increase of the temperature in the presence, of a specific disease. In addition to this variation in the individual animal, when the temperature of a number of hogs is compared the difference found is of such magnitude that we are at a loss to conclude what should be regarded as normal.

The hog is an animal that is ordinarily incased in a thick layer of fat, which is a poor conductor of heat and in which the circulation of blood is very meager. Over the fat a skin is stretched in which the circulation of blood is relatively small, and this skin, unlike that of a man or a horse, does not take a prominent part in regulating the bodily temperature through the agency of radiation and perspiration. The covering of a hog may be regarded rather as an excellent means for preventing the escape of heat from, than for regulating the temperature of, the body; hence we have conditions that probably permit of a more rapid production than escape of heat. If we bear this in mind we see how urgently necessary it is that hogs should be kept very quiet for some time before and throughout the duration of a tuberculin (temperature) test.

Normally it seems that fat hogs have a higher temperature than lean ones, and that a higher temperature induced by exercise or some other temporary cause persists longer in fat than in lean hogs.

These general remarks are based on numerous observations of hog temperatures made in the course of the last ten years on other hogs than those included in the tuberculin tests presented in this article.

PRECAUTIONS AGAINST FLUCTUATIONS OF TEMPERATURE.

In these experiments each hog was placed in a rectangular crate about twelve hours before the first temperature was taken, and remained in this confinement continuously until the tuberculin test was completed. The reason for confining the hogs during the tuberculin test was to keep them as quiet as possible, and to prevent increases of temperature incident to physical exertion and nervous excitement. The crates were large enough to permit the hogs to get up and down easily, narrow enough to keep them from turning around, and short enough to prevent too much movement backward and forward. The dimensions found to be satisfactory for hogs ranging in weight from 50 to 150 pounds are (interior measurement): Length, 4 feet; width, 1 foot 2 inches; height, 2 feet.

In the forward end of each crate a small trough for feeding and watering was fastened securely to the floor. The tops of the crates were fastened at the forward or head ends with hinges and at the rear with hasps and staples. At first an attempt was made to have a door at the rear end of each crate, to let down when the attendant was required to approach the hog to insert the thermometer into its rectum; but this arrangement was abandoned because it was found to be much easier to reach the hog from above. The material used in the construction of the crates was miscellaneous pieces of rough lumber 1 inch thick, wire nails, hinges, hasps, and staples. The only tools required were a hatchet and a saw.

Without the use of crates of the kind described, or some equally satisfactory means of restraint, it is difficult, if not impossible, to obtain reliable temperature records of hogs.

The extreme need of quiet is very well illustrated by the temperature of 17 hogs, taken at noon on one day after they had been confined eighteen hours in crates such as have been described, and at noon on another day when it was necessary to catch and hold them in pens 12 feet long by 4 feet wide. In the crates the average temperature was found to be 102.3° F., and in the pens 103.1° F., a difference of 0.8 degree, and this notwithstanding that the pens were very small and the hogs could be caught and held without exercising or exciting them very much.

THE TUBERCULIN TESTS.

The total number of hogs included in the tests was 58; of these 33 were killed and examined postmortem and 25 are still alive. The probability of the presence of disease among the latter has already been discussed (1 chance in 40 that a single one of the 25 hogs is tuberculous), and this is regarded as so remote that it would not be justifiable to sacrifice the hogs for postmortem examination in order to give to the conviction that they are healthy the value of a fully confirmed fact.

The temperature of the first 6 hogs tested was taken hourly for sixteen hours before they were injected with tuberculin, and again hourly for forty hours after the injection. The temperature of the next 14 hogs tested was taken for twenty-three hours before injection, and again hourly for thirty-two hours after injection. In the remaining tests the temperature was taken hourly for twenty-three hours before injection, and again hourly for twenty-five hours after injection. This elaborate system of taking and recording temperature will not be necessary with tuberculin tests of hogs for ordinary purposes; in the experimental tests its need is obvious.

The dose of tuberculin used for each hog was ½ c. c. of the regular tuberculin prepared by the Bureau of Animal Industry per hundredweight or fraction of a hundredweight of hog; that is, no hog received less than ½ c. c., and this was the dose used for all hogs the weight of which was 100 pounds or less; all hogs weighing more than 100 pounds but not more than 200 pounds received 1 c. c. No hog weighing more than 200 pounds was tested; if there had been, the dose would have been increased at the rate of ½ c. c. for every additional 100 pounds or fraction of the same.[a] The dose is relatively larger than that used for testing cattle, and was designedly made so because of the presumably tardier absorption from the subcutaneous tissues of hogs. The tuberculin injected into the hogs caused no objectionable results in a single instance. The seat of injection was directly under the skin that covers the inner surface of the right thigh.

ANALYSIS AND DISCUSSION OF RESULTS.

Among the 58 hogs tested, 26 were found on postmortem examination to be affected with tuberculosis. From the temperature records of the affected animals we obtain the following facts: After an injection with tuberculin the number of hours that pass before a reaction begins varies considerably, and the same is true about the time when the reaction reaches its maximum, and the number of hours during which the reaction persists. The average time when the temperature

[a] The dose of Bureau tuberculin for cattle is 2 c. c. for an adult animal; that is, about 1 c. c. per 200 pounds weight.

first rises above the maximum temperature before injection, and when the reaction reaches its maximum are, respectively, the seventh and the fourteenth hours after injection; and the average number of hours during which the reaction persists and the temperature remains higher than the highest temperature recorded before injection is twenty-three. If we divide the time of the reaction into two periods, one from its beginning to its maximum and the other from its maximum to its termination, we find that on an average the latter period is about twice as long as the former.

An examination of the degrees of temperature recorded after injection for the affected hogs shows that, with two exceptions (hogs Nos. 1754 and 1790), in every instance 105.0° F. was reached, and that the difference between the maximum temperature before injection and after injection in every case excepting two (hogs Nos. 1790 and 1853), was 1 degree or more. From this we conclude that, if the temperature after injection with tuberculin reaches 105.0° F. and is 1 degree higher than the maximum temperature on the previous day, the hog must be regarded as having given a reaction indicative of the presence of tuberculous disease. But as this formula excludes Nos. 1853, 1790, and 1754, it can not be regarded as altogether sufficient.

Hog No. 1853 had a temperature that reached 105.4° F. on the day before injection, and apart from the fact that this was under any circumstances an exceptionally high temperature, entirely too high to justify the application of the tuberculin test, it is shown by the temperature on the second day after injection that it was also an abnormally high temperature for the hog in question. The temperature after injection in this case, however, is so markedly influenced by the injection of tuberculin that very little judgment is required to conclude that a satisfactory reaction occurred, although the difference between the maximum before and after injection is only 0.6° F. We may say that 0.6 degree elevation after injection, above the highest temperature before injection, is a stronger reaction when the maximum before injection is above 105.0° F. than 1 degree when the maximum after injection does not reach higher than 105.0° F.

Hog No. 1790, in the presence of tuberculous disease, clearly failed to react. The lesions found in its body on autopsy, taken all together, would hardly make a mass the size of a pea; but it is just in such slightly affected cases that the reaction among cattle is often greatest, and this hog must be regarded strictly as an instance in which a satisfactory tuberculin failed to cause a temperature reaction.

Hog No. 1754, also a tuberculous animal, gave what would be regarded as a characteristic reaction for cattle; its temperature rose after injection to 1.2 degrees higher than on the day before, but as the highest temperature reached was only 103.8° F., if we keep the lack of constancy shown by hog temperature in mind this must be regarded

as a failure. A reaction of the kind given by this hog should lead to the diagnosis of tuberculosis if the history of the animal is one of exposure to infection; otherwise it must be regarded as negative, or as showing that the hog is free from tuberculosis. The truth of this assertion will be more apparent if we examine the temperature records of some of the healthy hogs, for example, Nos. 1874, 1886, and 1527, which showed a maximum temperature on the day before injection 1 degree or more higher than the maximum temperature on the day after injection. This shows that the movement of the temperature, under the most favorable circumstances for it to remain constant, of a degree or more, has no special diagnostic significance, and stamps hog No. 1754 all the more emphatically as a failure to react.

Hence we have, among the 26 hogs found to be tuberculous on autopsy, 24 hogs in which the presence of disease was clearly indicated by the tuberculin test, and 2 failures. The correct diagnosis represents a trifle more than 92 per cent, and the failures less than 8 per cent.

If we now apply the same system of analysis to the temperature records of the 32 healthy hogs, we find that only one reaction occurred, hog No. 1839, and this hog must justly be removed from the list. It was exposed to infection by eating infected food, and on autopsy was found to have a greatly enlarged and congested submaxillary lymph gland. The submaxillary glands have been shown by experience to be among the very first to become infected with tuberculosis when hogs are exposed to infection through the food they eat. No microscopic examination or inoculation tests with guinea pigs of the gland were made, because it was accidentally soiled during the autopsy of the hog by sectioning it with a knife that had been used to cut tuberculous tissue.

Two other hogs require a few words of explanation—Nos. 1876 and 1895. In both cases the temperature rose to 104.0° F. after injection, which was in the one case 1 degree and in the other 1.4 degrees higher than the maximum temperature before injection. Hog No. 1895, in which the difference of temperature on the day before and the day after injection was the greater, was examined postmortem and found to be perfectly healthy. The temperature of this hog in its gradual rise and decline after injection was very characteristic of a tuberculin reaction, while the elevation in the case of hog No. 1876 was erratic and did not partake of the general character of a reaction. If tuberculosis had been found in either hog the temperature records would have been regarded as failing to indicate its presence. For this reason, together with the failure of the maximum temperature to rise within a degree of the lowest maximum temperature reached during the tuberculin test by any hog affected with tuberculosis and regarded as having given a temperature reaction, these two cases can not be looked

upon as failures. A temperature record like that of hog No. 1895, obtained with a hog that is a member of a tuberculous herd, or is known to have been subjected to exposure, should, however, be regarded as very suspicious, and would justify the slaughter of the animal.

If we eliminate hog No. 1839 which reacted and about the tuberculous character of which some doubt remains, we have 31 healthy hogs that were tested with tuberculin, all of which failed to react, or successful determination of the absence of tuberculosis in 100 per cent of cases. The dependence that can be placed on tuberculin when the total number of hogs is considered, 26 tuberculous and 31 healthy, or 57 animals, among which two failures occurred, gives us the high figure of 96.49 per cent.

Ten of the hogs were tested a second time, about forty days after the conclusion of the first test. Of these, 6 reacted with both tests, 2 failed to react with both tests, and 2 failed with the first and reacted with the second test. The 6 that reacted with both tests were all tuberculous, the 2 that failed with both tests were free from disease, and the 2 that failed with the first and reacted with the second test were tuberculous. The latter 2 hogs belonged to Group III, and probably did not become affected with tuberculosis until after the first test was made. The lesions were all of a very recent character, and the disease, which usually progresses very rapidly in hogs exposed to the kind of tubercle bacillus with which these hogs became infected, was of limited extent.

The amount of time and labor required to make tuberculin tests in the elaborate manner that was practiced with the tests presented in this article is greatly in excess of what is practically necessary. It has been shown that the average length of time after injection for the reaction to begin is seven hours, that the maximum is reached seven hours later, and that the reaction continues sixteen hours after the maximum. The beginning and continuation of the reaction is regarded to be the uninterrupted elevation of the temperature actually above the maximum temperature recorded previous to injection.

If we reduce the number of times the temperature is taken, the three given figures should answer as a guide as to the best time to take it. Since the average number of hours after injection in which the maximum is reached is fourteen, the temperature should be taken in all tests on or about the fourteenth hour after injection; and since the time required for the temperature to rise from the beginning of a reaction to its maximum is only about half as long as the reaction endures after the maximum is reached, we may regard it as a rule that for every one time the temperature is taken before the fourteenth hour it should be taken two times after it.

If the reliability of our temperature records is estimated on the bases of the temperature recorded ten, twelve, fourteen, sixteen, eighteen, and twenty hours after injection with tuberculin, it will be found that they neither gain nor lose any portion of their diagnostic significance.

SUGGESTIONS FOR PRACTICAL APPLICATION OF THE TUBERCULIN TEST TO HOGS.

For a practical tuberculin test we suggest that the temperature of hogs be taken every two hours, from 8 a. m. to 6 p. m., inclusive, on the day of injection; that the tuberculin injection be made at 10 p. m., and the temperature again taken every two hours the day after injection from 8 a. m. to 6 p. m. The temperature before injection should be taken as frequently as after injection, and at corresponding hours, because of the very erratic character of the temperature of hogs, and because of the slight circumstances that may influence it to a very marked degree. And it is urged, above all things, that the hogs be kept very quiet throughout the entire test, and that the test be regarded in this connection to have its beginning at least twelve hours before the first temperature is taken.

Every man who uses tuberculin as a diagnostic agent must, of course, use a reasonable amount of judgment when he studies the significance of the temperature records he obtains, else he will meet with many disappointments and will soon come to undervalue the true reliability of this valuable substance.

Aside from the importance that must be attached to the difference between the maximum temperature before and after injection, the manner in which the temperature rises, the time it remains elevated, and the manner in which it drops back to normal must receive consideration. A single enormously high temperature, with a low temperature directly before and after it, is more apt to be an erratic occurrence without special significance than a tuberculin reaction. A reaction should show some persistence, though it need not remain at its maximum a long time. A good method, when doubt exists regarding the value of an elevation of temperature, is to subtract the sum of the degrees recorded before injection from the sum of the degrees recorded after injection, and to divide the remainder by the number of records made each day. For example, if we apply this method to hog No. 1853, and use the six temperature records obtained on each day at the hours recommended for a practical tuberculin test, we have the following:[a]

[a] The injection of tuberculin was made at 11 p. m., hence the tenth, twelfth, fourteenth, sixteenth, eighteenth, and twentieth hours after injection occur at 9 and 11 a. m., and 1, 3, 5, and 7 p. m.

Temperature of hog No. 1853.

Hour.	Temperature before injection.	Temperature after injection.
	° *F.*	° *F.*
9 a. m.	102.6	104.0
11 a. m.	103.6	105.0
1 p. m.	103.0	105.8
3 p. m.	104.2	106.0
5 p. m.	104.8	105.8
7 p. m.	105.4	103.8
Total	623.6	630.4

$$630.4-623.6=6.8$$
$$6.8\div6=1.13\tfrac{1}{3}$$

We see here that a persistent difference of 1.13⅓ degrees was present in this hog between the two days, notwithstanding that the difference between the maximum temperature recorded for each of the two days shows a difference of only 0.6 degree.

If we apply this same test to hog No. 1876, the maximum temperature of which on the day after injection was 1.6 degrees higher than on the previous day, we find that the persistent difference is only 0.26⅔ degree. Hence the great difference between the maximum records for the two days is dependent upon one erratic elevation on the day after injection, which should have no diagnostic significance.

Hog No. 1853 was tuberculous and hog No. 1876 was healthy.

If we apply this system of averaging the temperature to all the hogs, and leave the question of elevation to any particular point and the difference between daily maximum records entirely out of consideration, and insist on a persistent elevation of only 1 degree after injection, we will find that among our 68 tuberculin tests only two failures occurred, hog No. 1790, which failed to react in the presence of tuberculosis, and hog No. 1895, which reacted in the absence of tuberculosis.

For averaging the temperature in this manner it is necessary to use the same number of records for each day of the test, and preferably records made at corresponding hours. When the same number of records have not been made on each of the two days the sum for each day must first be divided by the number of records of which it consists and the subtraction made afterwards; that is, a simple method of subtracting the average temperature of one day from the average of the other must be used.

The following table is based on the suggestion made regarding the hours at which the temperature of hogs should be taken during a practical tuberculin test; that is, the reactions and failures to react are presented in the table by using only the temperature recorded in the general temperature tables for the tenth, twelfth, fourteenth, six-

teenth, eighteenth, and twentieth hours after injection with tuberculin, and the corresponding hours on the day before injection:

Results of tests compiled on basis proposed for practical tests.

Number of hog.	Maximum temperature. Before injection.	Maximum temperature. After injection.	Elevation of temperature in degrees F.	Reaction (+), or absence of reaction (−). (a)	Remarks.[b]
	° F.	° F.	° F.		
1853	105.4	106.0	0.6	[c] +	Tuberculous.
1854	105.4	107.2	1.8	+	Do.
1855	104.0	106.2	2.2	+	Do.
1856	103.6	106.2	2.6	+	Do.
1857	103.4	105.0	1.6	+	Do.
1858	103.6	104.0	0.4	−	Healthy.
1845	102.4	105.6	3.2	+	Tuberculous.
1846	103.2	107.4	4.2	+	Do.
1847	103.0	107.2	4.2	+	Do.
1848	103.4	107.6	4.2	+	Do.
1849	103.4	106.6	3.2	+	Do.
1850	103.6	106.6	3.0	+	Do.
1837	103.8	104.2	0.4	−	Healthy.
1838	103.0	103.2	0.2	−	Do.
1839	103.2	105.0	1.8	+	Probably tuberculous, diagnosis doubtful.
1840	103.8	103.4	−0.4	−	Healthy.
1841	103.2	103.6	0.4	−	Do.
1842	103.6	106.4	2.8	+	Tuberculous.
1843	103.0	103.8	0.8	−	First test; probably not tuberculous at this time.
	101.6	105.0	3.4	+	Second test; recent tuberculosis from feeding experiment.
1844	104.2	104.6	0.4	−	First test; same as hog No. 1843.
	103.6	106.6	3.0	+	Second test; same as hog No. 1843.
1877	103.4	103.2	−0.2	−	Healthy, alive.
1878	103.2	103.2	0.0	−	Do.
1879	102.8	102.8	0.0	−	Do.
1874	103.6	102.6	−1.0	−	Do.
1875	103.6	103.6	0.0	−	Do.
1876	102.4	104.0	1.6	−	Do.
1880	103.4	103.6	0.2	−	Do.
1881	103.0	102.4	−0.6	−	Do.
1883	103.4	103.0	−0.4	−	Do.
1884	103.0	102.8	−0.2	−	Do.
1885	103.4	103.2	−0.2	−	Do.
1886	103.8	102.4	−1.4	−	Do.
1887	103.8	103.6	−0.2	−	Do.
1888	103.6	103.6	0.0	−	Do.
1889	103.8	103.8	0.0	−	Do.
1891	103.4	102.8	−0.6	−	Do.
1751	102.6	106.2	3.6	+	Tuberculous.
1754	102.6	103.8	1.2	[d] −	Do.
1755	103.0	105.2	2.2	+	Do.
1772	102.4	105.6	3.2	+	Do.
1783	102.0	105.6	3.6	+	Do.
1790	101.6	102.8	1.2	[d] −	Do.
1798	103.2	106.0	2.8	+	Do.
1801	102.6	105.6	3.0	+	Do.
1803	103.6	106.0	2.4	+	Do.
1805	102.2	105.0	2.8	+	Do.
1809	102.8	106.4	3.6	+	Do.
1811	103.2	106.2	3.0	+	Do.

[a] The presence of a reaction is based on the elevation of the temperature on the day after injection to at least one degree above the maximum temperature of the previous day, and an actual elevation of the temperature to 105.0° F.

[b] Excepting when the statement is made that the hog is alive, the condition relative to the presence or absence of disease was determined by a postmortem examination.

[c] This one animal is made an exception to the above rule (*a*) because of the extremely high temperature before injection with tuberculin. Errors of diagnosis would probably be reduced if hogs with temperatures above 105° F. were excluded from the tuberculin test.

[d] Hogs Nos. 1754 and 1790, according to the foregoing rule (*a*) for determining the presence or absence of a reaction, are the only cases among the total of 68 tuberculin tests made and presented that failed to show a temperature condition in harmony with the presence or absence of tuberculosis. The results show that when the hogs are handled with care, and the temperature is taken at intervals of two hours only six times before injection and again at intervals of two hours six times after injection, the reliability of the tuberculin test for hogs is 97+ per cent.

Results of tests compiled on basis proposed for practical tests—Continued.

Number of hog.	Maximum temperature.		Elevation of temperature in degrees F.	Reaction (+), or absence of reaction (−).	Remarks.
	Before injection.	After injection.			
	° *F.*	° *F.*	° *F.*		
1383	101.8	101.4	−0.4	−	Healthy, alive.
1384	102.0	102.0	0.0	−	Do.
1385	103.0	102.4	−0.6	−	Do.
1399	101.4	102.0	0.6	−	Do.
1446	101.8	102.0	0.2	−	Do.
1527	102.6	101.4	−1.2	−	Do.
1895	102.2	103.8	1.6	−	Healthy on autopsy.
1896	102.2	101.4	−0.8	−	Healthy, alive.
1897	103.0	103.2	0.2	−	Do.
1898	103.2	103.4	0.2	−	Do.
1854	103.4	106.4	3.0	+	Second test; tuberculous.
1855	103.4	106.4	3.0	+	Do.
1856	104.4	105.4	1.0	+	Do.
1846	102.0	106.4	4.4	+	Do.
1848	103.6	105.6	2.0	+	Do.
1849	103.4	105.4	2.0	+	Do.
1838	102.2	101.6	−0.6	−	Second test; healthy.
1840	102.6	103.0	−0.4	−	Do.

COMPARATIVE VARIATION IN TEMPERATURES OF HOGS, OTHER ANIMALS, AND MEN.

The readiness with which the temperature of hogs rises and its erratic character is probably, in addition to other causes, to a great extent dependent upon the fact that they have relatively small lungs. When we think of the enormous surface that is exposed in the respiratory passages to the air we breathe, and the remarkable vascularity of this surface, we can not fail to receive the impression that one of the important functions of the organs of respiration is to aid in the regulation of the bodily temperature. The lung and the upper air passages are as nicely adapted for removing heat from the body, or for effecting the escape of the heat that is generated during the various metabolic processes, as an extensive network of pipes constantly immersed, in order to cool their contents, in a moving fluid of low temperature. The air we inspire is comparatively cool and dry; the air we expire is comparatively warm and moist; hence, the cooling process is dependent both upon the absorption of heat and upon the vaporization and the absorption by the air of moisture.

Panting or rapid breathing after exercise and during fever is less due to the need for an increased supply of oxygen than to an effort on the part of the respiratory organs to hasten the escape of heat. F. Smith, in his work on physiology, asserts that the percentage of oxygen lost and carbonic acid gained by the expired air during heavy work may fall below that observed in a state of repose, and attributes this circumstance to the larger volume of air that passes to and from the lung.

It is a well-known fact that the temperature of man is more constant than that of the lower animals; in his case a variation from the normal, which is a definitely established mark dealing with fractions of a degree, is either of very short duration or positively signifies that an abnormal process is active in his body. The reason for this is clearly apparent—a large respiratory surface, and an active, normally, almost bare or artificially covered skin. Among the domestic animals the horse, with its large lung and its active but covered skin, has a temperature that ranks next to that of man in regularity; and the hog, with its fat covered body, inert skin, and small lung, stands practically at the very end of the line of temperature constancy and regularity.

The following experiment was made to obtain further information on this point, and gives an emphatic illustration of the greater effect of exercise on the temperature of hogs than on that of man and other animals.

2 hogs were driven 200 meters (⅛ mile[a]) in 4 minutes.
2 men ran 400 meters (¼ mile) in 3 minutes.
2 horses were ridden 800 meters (½ mile) in 3 minutes.
2 cattle were driven 800 meters (½ mile) in 5 minutes.

The temperature records were as follows:

The temperatures of hogs, men, horses, and cattle before and after exercise.

	Hogs.		Men.		Horses.		Cattle.	
	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.
Before exercise	102.0	102.6	98.2	98.4	100.2	99.9	101.0	102.0
Immediately after	106.4	106.0	98.8	98.7	100.6	100.6	101.2	102.8
5 minutes after	106.4	105.8	99.0	98.6	101.4	101.3	101.8	103.0
10 minutes after	106.2	104.8	98.6	98.4	101.4	101.2	102.0	103.0
20 minutes after	104.6	104.4	98.6	98.4	101.2	101.0	102.0	103.0
30 minutes after	104.1	104.1	98.6	98.4	101.0	101.0	102.0	102.6
60 minutes after	103.8	103.6	98.6	98.4	100.6	100.8	102.0	102.4

The temperature of the two hogs the day following that on which the exercise was received, after they had been confined between eighteen and twenty hours in crates of the kind previously described, was: No. 1, 101.8° F.; No. 2, 102.4° F. The crates, immediately after this temperature was taken, with the hogs in them, were carefully lifted on a farm wagon and carried on the wagon back to the pens in which the hogs belonged, a distance of 200 meters, or one-eighth of a mile. As a result of the attendant excitement for the hogs, their temperature was raised: No. 1 to 102.4° F., and No. 2 to 103.2° F., an increase, respectively, of 0.6° and 0.8° F. The hogs were carefully taken from the crates, and just before releasing them in the pens their temperature was taken again, and was found to be: No. 1,

[a]This figure is not absolutely correct. 200 meters contain 656.166+ feet, and ⅛ mile 660 feet.

103.3° F., and No. 2, 103.8° F.; a further increase of 0.9° and 0.6° F., respectively. The whole process, taking temperature, moving the hogs, and turning them back into the pens, was accomplished in about thirty minutes, and was done in a quiet and methodical manner, and yet caused an increase in the temperature of the hogs, for No. 1 of 1.5° F., and for No. 2 of 1.4° F.

The effect of the exercise on the respiration of the men and several animals was as follows:

	Number of respirations per minute.		Approximate increase of volume of air breathed with each inspiration after exercise.
	Before exercise.	After exercise.	
Hogs	40 to 50	50 to 60	Four to five times the normal.
Men	18 to 20	28 to 30	Three to four times the normal.
Horses	12 to 14	40 to 50	No apparent increase.
Cattle	16 to 20	70 to 80	Do.

The effect on the respiration endured much longer with the hogs than with the men and other animals. The effect on the horses was of very short duration relative to the number of respirations, but before the breathing became entirely normal for a state of rest the increased rapidity was changed to an increased depth. The volume of air breathed by the cattle with each inspiration remained apparently constant.

It was impossible to obtain a record of the pulse beats for the hogs. The men showed an average increase from 78 beats per minute to 130, the horses from 36 to 70, and the cattle from 44 to 96. The return of the pulse and respiration to the normal for a state of rest was practically parallel.

It is a well-known fact that the energy required to do work increases very rapidly as the time in which it is done diminishes. For this reason, when the value of the results given in the tables is estimated, it must be borne in mind that the work done by the men in three minutes is twice that done by the hogs in four minutes, that done by the horses is four times as much in three minutes, and that by the cattle four times as much in five minutes.

The hogs used in this test were ordinary young farm animals of the kind and in the condition commonly found on American farms. The men were a clerk who leads a very sedentary life (No. 1) and a laborer (No. 2). Both men were thoroughly exhausted after the run, from what was for them an unusual form of exercise. The horses were a pair of heavy, quite fat, work animals, and did a kind of work to which they are accustomed, but did it at more than double the usual speed, and each horse carried on its back a man whose weight was at least 175 pounds. The cattle were a cow (No. 1) that had not been out

of her stall for several months and a heifer (No. 2) that was daily turned out in a small pasture.

The increase of temperature because of the exercise was as follows:

Hogs—
- No. 1, from 102.0 to 106.4=4.4 degrees.
- No. 2, from 102.6 to 106.0=3.4 degrees.

Men—
- No. 1, from 98.2 to 99.0=0.8 degree.
- No. 2, from 98.4 to 98.7=0.3 degree.

Horses—
- No. 1, from 100.2 to 101.4=1.2 degrees.
- No. 2, from 99.9 to 101.3=1.4 degrees.

Cattle—
- No. 1, from 101.0 to 102.0=1.0 degree.
- No. 2, from 102.0 to 103.0=1.0 degree.

The exercise given the horses—two fat, slow, work horses, each with a heavy man on its back, going half a mile at the rate of 10 miles an hour—is greatly in excess of that done by the men or the other animals, and consequently next to the hogs, they show the greatest elevation of temperature; but even in their case the elevation is incomparably less than in the hogs. If a walk, lasting four minutes, in which the distance covered is only one-eighth of a mile (the speed being less than 2 miles per hour), can elevate the temperature of a hog as much as 3.4 to 4.4 degrees (and that this is just what does occur we have experimentally demonstrated), our reiterated caution that hogs must be kept quiet, beginning some time before and during the entire course of a tuberculin test, will bear still another repetition. Without quiet an application of the tuberculin test will be found to be a hopeless, thankless, and unsatisfactory task from which no results can be gained, and which can lead to nothing but useless labor and a confused lot of temperature records from which no conclusions can be drawn. On the other hand, the tests we have made and presented clearly show that the tuberculin test has a high value, closely approaching absolute accuracy, when the hogs are treated in conformity with our suggestions.

TEMPERATURE AND AUTOPSY RECORDS.

The temperature records of all the hogs tested and the autopsy records of the 33 hogs that were killed and examined postmortem follow:

TEMPERATURE TABLES.

Table showing the temperature of hogs before and after injection.

HOG NO. 1853 (T).

Hour.	Feb. 14, before injection.	Feb. 15, after injection.	Feb. 16, after injection.
	°F.	°F.	°F.
1 a. m	....	104.4	103.4
2 a. m	....	103.4	104.4
3 a. m	....	102.6	104.6
4 a. m	....	103.0	104.6
5 a. m	....	103.2	103.0
6 a. m	....	104.0	103.2
7 a. m	....	102.4	103.0
8 a. m	102.0	104.8	103.4
9 a. m	102.6	104.0	103.6
10 a. m	103.8	105.6	104.0
11 a. m	103.6	105.0	103.8
12 m	102.6	105.6	104.6
1 p. m	103.0	105.8	104.2
2 p. m	103.4	106.0	104.0
3 p. m	104.2	106.0	104.0
4 p. m	105.0	106.0	103.8
5 p. m	104.8	105.8	....
6 p. m	105.4	105.0	....
7 p. m	105.4	103.8	....
8 p. m	105.0	102.6	....
9 p. m	104.6	104.4	....
10 p. m	104.0	105.6	....
11 p. m	[a] 104.2	103.2	....
12 p. m	104.0	103.4	....

HOG NO. 1855. (T.)

Hour.	Feb. 14, before injection.	Feb. 15, after injection.	Feb. 16, after injection.
	°F.	°F.	°F.
1 a. m	....	104.0	104.6
2 a. m	....	104.6	104.6
3 a. m	....	104.0	105.6
4 a. m	....	105.0	104.6
5 a. m	....	105.4	104.0
6 a. m	....	106.2	104.0
7 a. m	....	106.2	104.2
8 a. m	104.6	105.0	103.6
9 a. m	103.8	106.4	104.4
10 a. m	103.4	106.2	103.6
11 a. m	103.8	106.0	104.0
12 m	103.8	106.4	104.0
1 p. m	103.8	106.2	104.2
2 p. m	103.4	106.6	104.2
3 p. m	103.6	106.2	103.8
4 p. m	103.6	107.0	104.0
5 p. m	103.8	105.4	....
6 p. m	103.6	106.0	....
7 p. m	104.0	105.8	....
8 p. m	104.2	105.8	....
9 p. m	103.8	106.0	....
10 p. m	104.6	106.0	....
11 p. m	[a] 104.6	105.0	....
12 p. m	104.2	105.6	....

HOG NO. 1854 (T).

Hour.	Feb. 14, before injection.	Feb. 15, after injection.	Feb. 16, after injection.
	°F.	°F.	°F.
1 a. m	....	104.0	105.6
2 a. m	....	105.0	105.4
3 a. m	....	104.4	105.6
4 a. m	....	104.2	104.6
5 a. m	....	105.0	104.8
6 a. m	....	104.4	104.6
7 a. m	....	105.4	104.6
8 a. m	104.0	105.2	104.2
9 a. m	104.4	105.4	104.2
10 a. m	104.6	106.0	104.0
11 a. m	104.6	106.2	103.8
12 m	104.0	107.8	104.2
1 p. m	103.8	106.8	104.0
2 p. m	103.4	107.2	104.0
3 p. m	103.4	107.2	104.2
4 p. m	105.0	106.8	104.0
5 p. m	105.4	105.8	....
6 p. m	104.8	106.6	....
7 p. m	105.0	106.0	....
8 p. m	104.4	106.0	....
9 p. m	103.8	107.0	....
10 p. m	104.4	106.2	....
11 p. m	[a] 104.2	106.4	....
12 p. m	104.6	106.0	....

HOG NO. 1856. (T.)

Hour.	Feb. 14, before injection.	Feb. 15, after injection.	Feb. 16, after injection.
	°F.	°F.	°F.
1 a. m	....	102.8	104.4
2 a. m	....	103.0	103.8
3 a. m	....	103.2	102.4
4 a. m	....	103.0	102.2
5 a. m	....	102.6	102.8
6 a. m	....	103.6	102.2
7 a. m	....	104.6	102.4
8 a. m	102.2	105.0	102.2
9 a. m	102.2	106.2	102.6
10 a. m	102.8	105.8	102.6
11 a. m	103.6	106.2	103.6
12 m	103.0	106.0	103.6
1 p. m	102.8	105.8	103.8
2 p. m	103.2	105.8	103.4
3 p. m	103.4	106.0	103.4
4 p. m	103.4	106.0	104.0
5 p. m	103.0	105.2	....
6 p. m	102.6	105.0	....
7 p. m	103.4	104.4	....
8 p. m	103.0	104.2	....
9 p. m	103.0	104.4	....
10 p. m	102.6	104.4	....
11 p. m	[a] 102.6	104.0	....
12 p. m	103.0	104.8	....

[a] Injected with ½ c. c. of tuberculin at this hour.

NOTE.—The letter (T) placed after the number of a hog signifies that it was found to be affected with tuberculosis when examined postmortem. The letter (H) after the number of a hog signifies that it was found to be free from tuberculous disease on postmortem examination. The letter (A) after the number of a hog signifies that it is alive, and without doubt free from tuberculosis or other disease.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1857. (T.)

Hour.	Feb. 14, before injection.	Feb. 15, after injection.	Feb. 16, after injection.
	°*F.*	°*F.*	°*F.*
1 a. m	....	103.2	103.6
2 a. m	....	103.2	104.0
3 a. m	....	103.2	104.0
4 a. m	....	104.4	103.4
5 a. m	....	103.4	103.8
6 a. m	....	102.6	103.6
7 a. m	....	102.6	104.0
8 a. m	103.0	103.0	103.8
9 a. m	103.4	103.6	104.0
10 a. m	103.6	104.2	103.4
11 a. m	103.0	104.0	104.0
12 m	103.4	104.6	103.2
1 p. m	102.0	104.6	103.8
2 p. m	102.2	104.6	103.6
3 p. m	102.6	104.0	103.2
4 p. m	103.6	104.2	103.4
5 p. m	103.0	103.6	....
6 p. m	102.6	104.0	....
7 p. m	103.2	105.0	....
8 p. m	102.6	103.8	....
9 p. m	103.0	104.4	....
10 p. m	102.6	104.4	....
11 p. m	[a] 102.2	104.2	....
12 p. m	103.2	104.0	....

HOG NO. 1845. (T.)

Hour.	Feb. 20, before injection.	Feb. 21, after injection.	Feb. 22, after injection.
	°*F.*	°*F.*	°*F.*
1 a. m	100.4	101.0	104.4
2 a. m	100.2	100.8	104.4
3 a. m	100.6	100.4	104.6
4 a. m	100.6	100.6	104.4
5 a. m	101.2	102.0	104.4
6 a. m	101.2	102.4	104.4
7 a. m	101.2	102.0	104.0
8 a. m	102.4	102.6	104.2
9 a. m	102.4	103.0	....
10 a. m	101.4	104.4	....
11 a. m	101.4	104.4	....
12 m	102.0	104.8	....
1 p. m	101.6	105.2	....
2 p. m	101.6	105.0	....
3 p. m	101.8	105.6	....
4 p. m	102.2	103.2	....
5 p. m	102.4	103.2	....
6 p. m	101.8	104.4	....
7 p. m	101.8	104.4	....
8 p. m	101.6	105.2	....
9 p. m	101.4	104.4	....
10 p. m	101.4	104.8	....
11 p. m	[a] 101.6	105.0	....
12 p. m	101.6	104.8	....

HOG NO. 1858. (H.)

Hour.	Feb. 14, before injection.	Feb. 15, after injection.	Feb. 16, after injection.
	°*F.*	°*F.*	°*F.*
1 a. m	....	103.4	104.2
2 a. m	....	103.4	104.0
3 a. m	....	103.2	104.0
4 a. m	....	103.0	104.0
5 a. m	....	103.8	104.0
6 a. m	....	103.8	104.0
7 a. m	....	103.6	104.2
8 a. m	103.2	103.6	103.6
9 a. m	102.8	103.4	104.0
10 a. m	103.4	103.2	103.2
11 a. m	103.2	103.6	104.0
12 m	103.2	103.8	103.4
1 p. m	103.0	103.4	102.8
2 p. m	102.6	104.4	103.4
3 p. m	103.6	104.0	103.4
4 p. m	103.4	104.0	103.2
5 p. m	103.4	104.0	....
6 p. m	103.6	104.2	....
7 p. m	103.6	104.0	....
8 p. m	104.0	103.4	....
9 p. m	103.6	104.4	....
10 p. m	103.2	104.6	....
11 p. m	[a] 103.6	104.4	....
12 p. m	103.8	103.8	....

HOG NO. 1846. (T.)

Hour.	Feb. 20, before injection.	Feb. 21, after injection.	Feb. 22, after injection.
	°*F.*	°*F.*	°*F.*
1 a. m	102.4	102.0	105.0
2 a. m	102.6	102.2	104.6
3 a. m	101.2	102.0	104.0
4 a. m	102.4	102.2	104.0
5 a. m	102.6	102.6	103.8
6 a. m	102.4	104.6	103.6
7 a. m	102.4	105.8	103.2
8 a. m	102.8	106.6	103.2
9 a. m	103.2	107.0	....
10 a. m	103.0	107.0	....
11 a. m	102.8	107.2	....
12 m	102.4	107.6	....
1 p. m	102.4	107.4	....
2 p. m	102.4	106.8	....
3 p. m	102.0	107.4	....
4 p. m	102.6	107.0	....
5 p. m	102.2	106.4	....
6 p. m	102.2	106.6	....
7 p. m	101.8	106.4	....
8 p. m	102.0	105.8	....
9 p. m	101.8	105.8	....
10 p. m	101.6	104.8	....
11 p. m	[a] 101.4	104.6	....
12 p. m	102.0	105.0	....

[a] Injected with ½ c. c. of tuberculin at this hour.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1847. (T.)				HOG NO. 1849. (T.)			
Hour.	Feb. 20, before injection.	Feb. 21, after injection.	Feb. 22, after injection.	Hour.	Feb. 20, before injection.	Feb. 21, after injection.	Feb. 22, after injection.
	°F.	°F.	°F.		°F.	°F.	°F.
1 a. m	100.4	101.4	106.2	1 a. m	101.2	102.0	105.8
2 a. m	101.2	101.6	106.0	2 a. m	101.2	101.8	105.2
3 a. m	102.0	102.0	106.0	3 a. m	101.4	102.2	104.8
4 a. m	101.6	102.0	106.0	4 a. m	102.0	102.2	104.6
5 a. m	101.2	102.4	105.8	5 a. m	101.6	102.6	104.6
6 a. m	101.2	103.0	105.8	6 a. m	102.2	103.0	104.2
7 a. m	101.6	104.0	104.6	7 a. m	102.6	103.2	103.4
8 a. m	102.0	105.2	104.2	8 a. m	102.8	103.4	103.6
9 a. m	103.0	105.6	....	9 a. m	103.4	104.0	....
10 a. m	102.2	106.4	....	10 a. m	102.8	105.0	....
11 a. m	102.8	107.0	....	11 a. m	102.6	105.8	....
12 m	102.2	107.0	....	12 m	102.8	106.0	....
1 p. m	102.4	107.2	....	1 p. m	102.6	106.0	....
2 p. m	102.4	106.4	....	2 p. m	102.4	106.2	....
3 p. m	102.2	107.0	....	3 p. m	102.2	106.0	....
4 p. m	102.8	106.6	....	4 p. m	102.4	105.8	....
5 p. m	102.4	106.4	....	5 p. m	103.0	106.6	....
6 p. m	102.2	106.4	....	6 p. m	103.0	107.0	....
7 p. m	102.0	106.2	....	7 p. m	102.6	106.0	....
8 p. m	101.8	106.0	....	8 p. m	102.4	106.0	....
9 p. m	101.8	105.4	....	9 p. m	102.4	105.8	....
10 p. m	101.6	106.4	....	10 p. m	102.2	106.0	....
11 p. m	*a*102.2	106.2	....	11 p. m	*a*102.2	106.0	....
12 p. m	101.6	106.8	....	12 p. m	102.4	105.2	....
HOG NO. 1848. (T.)				HOG NO. 1850. (T.)			
	°F.	°F.	°F.		°F.	°F.	°F.
1 a. m	102.4	102.4	103.4	1 a. m	102.2	102.4	106.2
2 a. m	102.4	102.8	103.6	2 a. m	102.4	102.4	106.0
3 a. m	102.8	103.6	103.2	3 a. m	102.2	102.6	105.4
4 a. m	102.8	103.4	103.2	4 a. m	102.4	102.8	105.2
5 a. m	102.8	104.8	102.2	5 a. m	102.4	102.6	105.4
6 a. m	102.8	106.0	102.4	6 a. m	102.8	103.0	104.8
7 a. m	102.6	106.2	103.2	7 a. m	102.6	103.4	104.8
8 a. m	103.0	106.2	103.4	8 a. m	103.4	104.0	104.8
9 a. m	103.4	106.6	....	9 a. m	103.6	105.0	....
10 a. m	103.0	107.2	....	10 a. m	103.0	105.4	....
11 a. m	102.8	107.2	....	11 a. m	103.0	105.6	....
12 m	102.6	107.4	....	12 m	102.8	106.2	....
1 p. m	102.6	107.0	....	1 p. m	102.4	105.6	....
2 p. m	102.8	107.6	....	2 p. m	102.8	106.6	....
3 p. m	102.8	107.6	....	3 p. m	103.2	106.4	....
4 p. m	102.6	105.6	....	4 p. m	102.8	106.0	....
5 p. m	103.2	106.4	....	5 p. m	102.8	105.0	....
6 p. m	102.8	106.4	....	6 p. m	102.2	106.4	....
7 p. m	103.0	106.4	....	7 p. m	102.0	106.6	....
8 p. m	102.8	106.0	....	8 p. m	102.2	106.4	....
9 p. m	102.0	105.8	....	9 p. m	102.4	106.6	....
10 p. m	102.4	104.8	....	10 p. m	102.2	106.0	....
11 p. m	*a*102.0	104.4	....	11 p. m	*a*102.4	106.0	....
12 p. m	102.4	104.0	....	12 p. m	102.6	106.0	....

a Injected with ½ c. c. of tuberculin at this hour.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1837. (H.)

Hour.	Feb. 27, before injection.	Feb. 28, after injection.	Mar. 1, after injection.
	°*F.*	°*F.*	°*F.*
1 a. m.	102.4	103.2	102.6
2 a. m.	101.6	102.4	102.6
3 a. m.	102.2	102.4	103.2
4 a. m.	102.6	102.4	102.6
5 a. m.	102.6	102.4	102.4
6 a. m.	102.6	102.4	102.2
7 a. m.	102.6	103.2	102.0
8 a. m.	102.8	104.2	....
9 a. m.	103.4	104.2	....
10 a. m.	102.6	103.4	....
11 a. m.	103.2	104.0	....
12 m.	102.4	103.6	....
1 p. m.	103.8	103.6	....
2 p. m.	103.2	103.0	....
3 p. m.	103.0	103.0	....
4 p. m.	103.4	103.6	....
5 p. m.	103.4	103.4	....
6 p. m.	102.8	102.6	....
7 p. m.	102.4	103.0	....
8 p. m.	102.6	103.0	....
9 p. m.	102.0	102.8	....
10 p. m.	103.2	102.4	....
11 p. m.	[a] 103.6	102.4	....
12 p. m.	103.8	102.4	....

HOG NO. 1839. (?)[b]

Hour.	Feb. 27, before injection.	Feb. 28, after injection.	Mar. 1, after injection.
	°*F.*	°*F.*	°*F.*
1 a. m.	102.4	103.6	102.6
2 a. m.	101.4	102.2	103.0
3 a. m.	102.0	102.6	103.6
4 a. m.	103.4	102.4	104.2
5 a. m.	102.4	103.4	103.6
6 a. m.	102.2	104.0	103.6
7 a. m.	103.4	103.6	104.2
8 a. m.	103.8	103.6	....
9 a. m.	103.2	104.0	....
10 a. m.	102.4	104.2	....
11 a. m.	102.8	103.8	....
12 m.	103.0	104.2	....
1 p. m.	102.4	104.0	....
2 p. m.	102.0	105.0	....
3 p. m.	102.8	104.6	....
4 p. m.	102.0	104.6	....
5 p. m.	102.0	105.0	....
6 p. m.	102.0	103.4	....
7 p. m.	101.8	103.6	....
8 p. m.	102.0	103.4	....
9 p. m.	101.8	104.0	....
10 p. m.	102.4	104.6	....
11 p. m.	[a] 102.0	103.4	....
12 p. m.	103.0	103.6	....

HOG NO. 1838. (H.)

Hour.	Feb. 27, before injection.	Feb. 28, after injection.	Mar. 1, after injection.
	°*F.*	°*F.*	°*F.*
1 a. m.	102.0	102.0	101.6
2 a. m.	101.6	101.6	102.0
3 a. m.	101.2	101.6	102.2
4 a. m.	101.0	101.4	101.8
5 a. m.	101.4	101.8	102.0
6 a. m.	102.4	102.4	102.4
7 a. m.	102.6	102.4	102.0
8 a. m.	102.8	103.0	....
9 a. m.	102.4	103.0	....
10 a. m.	103.2	102.0	....
11 a. m.	102.6	103.0	....
12 m.	102.2	103.2	....
1 p. m.	102.2	103.0	....
2 p. m.	102.0	103.0	....
3 p. m.	102.0	103.0	....
4 p. m.	102.4	103.0	....
5 p. m.	103.0	103.2	....
6 p. m.	101.6	102.6	....
7 p. m.	101.4	102.2	....
8 p. m.	101.8	102.0	....
9 p. m.	101.2	102.2	....
10 p. m.	101.8	101.4	....
11 p. m.	[a] 101.8	101.8	....
2 p. m.	102.2	102.4	....

HOG NO. 1840. (H.)

Hour.	Feb. 27, before injection.	Feb. 28, after injection.	Mar. 1, after injection.
	°*F.*	°*F.*	°*F.*
1 a. m.	103.4	103.0	103.0
2 a. m.	103.0	102.8	102.4
3 a. m.	103.0	103.0	102.8
4 a. m.	103.0	102.4	103.0
5 a. m.	103.0	102.4	103.0
6 a. m.	103.2	102.4	102.4
7 a. m.	103.2	103.4	102.8
8 a. m.	103.6	103.0	....
9 a. m.	103.8	102.6	....
10 a. m.	103.2	102.6	....
11 a. m.	102.8	103.2	....
12 m.	103.4	103.2	....
1 p. m.	103.2	103.4	....
2 p. m.	103.6	103.0	....
3 p. m.	102.8	103.0	....
4 p. m.	102.6	103.0	....
5 p. m.	103.6	103.4	....
6 p. m.	102.8	103.6	....
7 p. m.	103.2	103.2	....
8 p. m.	102.8	103.4	....
9 p. m.	102.6	103.0	....
10 p. m.	102.2	103.0	....
11 p. m.	[a] 103.2	102.4	....
12 p. m.	103.0	102.8	....

[a] Injected with ⅓ c. c. of tuberculin at this hour.
[b] Probably affected with very recent tuberculosis.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1841. (H.)

Hour.	Feb. 27, before injection.	Feb. 28, after injection.	Mar. 1, after injection.
	°*F.*	°*F.*	°*F.*
1 a. m.	100.6	102.0	102.8
2 a. m.	101.4	102.8	102.0
3 a. m.	102.0	102.2	102.0
4 a. m.	102.4	101.4	101.8
5 a. m.	102.4	101.4	101.0
6 a. m.	101.6	101.2	101.2
7 a. m.	102.2	101.2	101.0
8 a. m.	101.6	102.0	....
9 a. m.	101.8	102.6	....
10 a. m.	101.0	102.6	....
11 a. m.	101.8	102.6	....
12 m	102.6	103.6	....
1 p. m.	102.8	103.0	....
2 p. m.	102.4	103.0	....
3 p. m.	102.8	103.0	....
4 p. m.	102.6	103.6	....
5 p. m.	103.2	103.6	....
6 p. m.	102.8	103.8	....
7 p. m.	103.0	102.6	....
8 p. m.	102.8	102.8	....
9 p. m.	102.4	103.4	....
10 p. m.	102.4	103.0	....
11 p. m.	[a]102.4	103.2	....
12 p. m.	102.4	102.0	....

HOG NO. 1843. (T.)[b]

Hour.	Feb. 27, before injection.	Feb. 28, after injection.	Mar. 1, after injection.
	°*F.*	°*F.*	°*F.*
1 a. m	103.6	103.0	103.2
2 a. m	103.6	103.4	102.8
3 a. m	103.0	102.8	103.0
4 a. m	103.2	102.4	103.6
5 a. m	103.0	102.4	103.2
6 a. m	104.0	102.0	103.2
7 a. m	103.4	102.4	103.2
8 a. m	103.6	104.2	....
9 a. m	103.0	103.6	....
10 a. m	103.2	104.0	....
11 a. m	102.6	103.0	....
12 m	102.6	104.0	....
1 p. m	102.4	103.6	....
2 p. m	102.2	103.0	....
3 p. m	103.0	103.2	....
4 p. m	102.8	103.0	....
5 p. m	103.0	103.8	....
6 p. m	103.2	103.2	....
7 p. m	102.6	102.8	....
8 p. m	102.2	103.4	....
9 p. m	102.8	103.2	....
10 p. m	102.4	102.8	....
11 p. m	[a]103.4	102.6	....
12 p. m	103.8	103.2	....

HOG NO. 1842. (T.)

Hour.	Feb. 27, before injection.	Feb. 28, after injection.	Mar. 1, after injection.
	°*F.*	°*F.*	°*F.*
1 a. m.	104.4	104.0	104.4
2 a. m.	104.0	103.8	105.0
3 a. m.	104.4	104.0	104.8
4 a. m.	104.2	103.8	104.2
5 a. m.	104.0	103.8	104.2
6 a. m.	104.0	103.8	103.4
7 a. m.	103.8	103.8	103.4
8 a. m.	103.6	103.8	....
9 a. m.	103.6	105.6	....
10 a. m.	103.2	105.0	....
11 a. m.	103.2	104.4	....
12 m	103.6	106.0	....
1 p. m.	103.4	106.0	....
2 p. m.	103.6	106.0	....
3 p. m.	103.0	105.2	....
4 p. m.	103.2	106.4	....
5 p. m.	102.6	106.4	....
6 p. m.	103.0	106.4	....
7 p. m.	103.0	106.0	....
8 p. m.	103.0	105.8	....
9 p. m.	103.2	106.6	....
10 p. m.	102.8	105.0	....
11 p. m.	[a]103.8	105.4	....
12 p. m.	103.4	105.0	....

HOG NO. 1844. (T.)[b]

Hour.	Feb. 27, before injection.	Feb. 28, after injection.	Mar. 1, after injection.
	°*F.*	°*F.*	°*F.*
1 a. m	103.0	103.8	104.0
2 a. m	104.0	103.8	103.6
3 a. m	103.6	103.8	103.8
4 a. m	103.8	103.4	103.4
5 a. m	104.4	104.0	104.2
6 a. m	104.2	104.2	104.2
7 a. m	104.0	103.4	104.2
8 a. m	104.6	104.2	....
9 a. m	104.0	104.0	....
10 a. m	104.6	104.2	....
11 a. m	104.2	104.0	....
12 m	103.6	104.2	....
1 p. m	104.2	104.0	....
2 p. m	104.6	104.8	....
3 p. m	103.8	104.0	....
4 p. m	103.2	104.6	....
5 p. m	103.6	104.6	....
6 p. m	103.4	104.4	....
7 p. m	104.0	104.6	....
8 p. m	103.2	104.2	....
9 p. m	103.2	103.8	....
10 p. m	103.0	104.4	....
11 p. m	[a]103.6	103.4	....
12 p. m	103.8	104.2	....

[a] Injected with $\frac{1}{8}$ c. c. of tuberculin at this hour.

[b] See also second test of this hog. Probably contracted tuberculosis after the first test and before the second.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1874. (A.)

Hour.	Mar. 6, before injection.	Mar. 7, after injection.
	°F.	°F.
1 a. m	102.6	101.6
2 a. m	102.4	101.2
3 a. m	102.8	100.8
4 a. m	102.2	102.0
5 a. m	102.4	101.6
6 a. m	101.8	101.0
7 a. m	102.4	101.4
8 a. m	102.0	102.2
9 a. m	103.6	102.0
10 a. m	103.6	102.2
11 a. m	103.6	102.6
12 m	102.0	102.0
1 p. m	101.8	102.4
2 p. m	102.8	102.0
3 p. m	102.6	102.0
4 p. m	102.6	102.0
5 p. m	103.0	102.4
6 p. m	102.4	102.0
7 p. m	102.0	101.8
8 p. m	101.8	102.4
9 p. m	101.8	101.2
10 p. m	101.4	100.8
11 p. m	[a] 101.4	101.2
12 p. m	101.8	101.2

HOG NO. 1876. (A.)

Hour.	Mar. 6, before injection.	Mar. 7, after injection.
	°F.	°F.
1 a. m	100.8	101.8
2 a. m	100.8	101.2
3 a. m	101.0	101.6
4 a. m	101.0	101.2
5 a. m	101.2	101.2
6 a. m	101.6	101.4
7 a. m	101.8	102.0
8 a. m	101.8	102.0
9 a. m	102.2	102.0
10 a. m	102.0	103.0
11 a. m	102.0	104.0
12 m	103.0	103.6
1 p. m	102.0	102.6
2 p. m	102.6	102.0
3 p. m	102.0	101.8
4 p. m	102.4	102.0
5 p. m	102.4	102.4
6 p. m	102.0	102.0
7 p. m	102.4	101.8
8 p. m	102.0	101.6
9 p. m	101.6	101.4
10 p. m	101.8	101.0
11 p. m	[a] 101.6	101.0
12 p. m	101.6	101.2

HOG NO. 1875. (A.)

Hour.	Mar. 6, before injection.	Mar. 7, after injection.
	°F.	°F.
1 a. m	102.4	101.6
2 a. m	101.8	101.0
3 a. m	102.6	101.4
4 a. m	101.8	101.8
5 a. m	101.8	101.6
6 a. m	100.8	101.6
7 a. m	101.2	102.8
8 a. m	102.0	102.8
9 a. m	103.0	102.8
10 a. m	102.8	102.8
11 a. m	103.0	103.0
12 m	102.8	102.8
1 p. m	102.4	102.8
2 p. m	102.6	103.2
3 p. m	103.0	103.6
4 p. m	103.2	103.4
5 p. m	103.6	102.6
6 p. m	103.6	102.8
7 p. m	103.4	102.8
8 p. m	103.4	102.8
9 p. m	102.0	103.0
10 p. m	102.0	102.4
11 p. m	[a] 102.0	102.2
12 p. m	102.0	102.2

HOG NO. 1877. (A.)

Hour.	Mar. 6, before injection.	Mar. 7, after injection.
	°F.	°F.
1 a. m	101.8	102.2
2 a. m	102.2	101.8
3 a. m	102.0	101.6
4 a. m	101.8	101.8
5 a. m	101.4	102.6
6 a. m	102.4	102.4
7 a. m	103.2	101.6
8 a. m	102.2	101.6
9 a. m	103.4	101.8
10 a. m	102.8	102.6
11 a. m	102.6	103.2
12 m	103.0	102.6
1 p. m	102.8	102.0
2 p. m	102.8	102.6
3 p. m	102.0	103.0
4 p. m	103.0	102.2
5 p. m	102.6	102.4
6 p. m	102.6	102.0
7 p. m	102.0	102.0
8 p. m	102.2	102.2
9 p. m	102.6	101.6
10 p. m	101.6	102.2
11 p. m	[a] 102.4	102.0
12 p. m	102.0	102.0

[a] Injected with ½ c. c. of tuberculin at this hour.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1878. (A.)			HOG NO. 1880. (A.)		
Hour.	Mar. 6, before injection.	Mar. 7, after injection.	Hour.	Mar. 6, before injection.	Mar. 7, after injection.
	°F.	°F.		°F.	°F.
1 a. m.	101.0	103.0	1 a. m.	102.0	103.4
2 a. m.	102.0	103.0	2 a. m.	103.2	103.2
3 a. m.	101.8	103.0	3 a. m.	103.0	103.0
4 a. m.	101.8	102.8	4 a. m.	102.6	103.4
5 a. m.	102.0	102.6	5 a. m.	102.6	103.0
6 a. m.	102.4	102.8	6 a. m.	102.4	103.2
7 a. m.	102.6	102.8	7 a. m.	102.4	103.4
8 a. m.	103.4	103.4	8 a. m.	103.2	103.6
9 a. m.	103.2	103.2	9 a. m.	103.0	103.4
10 a. m.	102.0	102.2	10 a. m.	103.2	103.6
11 a. m.	102.2	102.8	11 a. m.	103.0	103.6
12 m.	102.4	103.0	12 m.	103.2	103.0
1 p. m.	102.2	102.8	1 p. m.	103.2	103.0
2 p. m.	102.4	102.0	2 p. m.	103.2	102.8
3 p. m.	102.4	102.4	3 p. m.	103.0	103.4
4 p. m.	103.4	103.0	4 p. m.	103.0	103.4
5 p. m.	103.0	103.0	5 p. m.	103.4	103.0
6 p. m.	102.6	103.0	6 p. m.	103.0	102.8
7 p. m.	102.6	102.6	7 p. m.	103.2	102.8
8 p. m.	102.8	102.8	8 p. m.	103.0	102.8
9 p. m.	102.4	102.4	9 p. m.	103.4	102.4
10 p. m.	102.0	102.2	10 p. m.	102.4	103.2
11 p. m.	a 102.4	102.2	11 p. m.	a 102.6	102.8
12 p. m.	103.0	102.2	12 p. m.	103.2	102.6
HOG NO. 1879. (A.)			HOG NO. 1881. (A.)		
	°F.	°F.		°F.	°F.
1 a. m.	102.4	102.0	1 a. m.	102.4	102.6
2 a. m.	102.8	101.6	2 a. m.	102.0	102.2
3 a. m.	101.6	102.0	3 a. m.	101.6	102.2
4 a. m.	101.2	102.4	4 a. m.	101.6	102.0
5 a. m.	101.2	102.2	5 a. m.	102.2	102.8
6 a. m.	100.8	102.0	6 a. m.	102.6	102.4
7 a. m.	100.6	102.2	7 a. m.	102.6	102.6
8 a. m.	101.8	102.8	8 a. m.	102.8	102.2
9 a. m.	102.0	102.4	9 a. m.	103.0	102.4
10 a. m.	101.6	102.4	10 a. m.	102.8	102.4
11 a. m.	102.0	102.4	11 a. m.	103.0	102.4
12 m.	102.4	102.2	12 m.	103.2	101.4
1 p. m.	102.0	102.0	1 p. m.	103.0	101.4
2 p. m.	102.0	102.0	2 p. m.	102.8	101.6
3 p. m.	102.2	102.2	3 p. m.	102.8	101.4
4 p. m.	102.4	102.0	4 p. m.	102.6	102.0
5 p. m.	102.8	102.8	5 p. m.	102.4	102.2
6 p. m.	102.8	101.8	6 p. m.	102.6	101.6
7 p. m.	102.6	102.2	7 p. m.	102.2	101.6
8 p. m.	102.4	102.0	8 p. m.	102.0	101.2
9 p. m.	102.6	102.0	9 p. m.	102.4	101.4
10 p. m.	102.4	102.0	10 p. m.	102.8	101.4
11 p. m.	a 102.4	102.0	11 p. m.	a 102.0	101.6
12 p. m.	102.2	102.0	12 p. m.	101.6	101.4

a Injected with ¼ c. c. of tuberculin at this hour.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1883. (A.)

Hour.	Mar. 6, before injection.	Mar. 7, after injection.
	° *F.*	° *F.*
1 a.m.	102.2	103.2
2 a.m.	102.0	103.2
3 a.m.	101.8	103.0
4 a.m.	102.2	103.0
5 a.m.	102.6	103.2
6 a.m.	102.6	102.8
7 a.m.	102.0	102.6
8 a.m.	103.0	102.8
9 a.m.	103.4	103.0
10 a.m.	103.4	102.8
11 a.m.	102.8	102.6
12 m.	102.6	102.8
1 p.m.	102.6	102.4
2 p.m.	102.4	102.4
3 p.m.	103.0	102.2
4 p.m.	103.0	102.0
5 p.m.	103.2	102.4
6 p.m.	103.0	102.6
7 p.m.	103.2	102.2
8 p.m.	103.0	102.4
9 p.m.	103.0	102.6
10 p.m.	103.0	102.2
11 p.m.	[a] 103.2	103.0
12 p.m.	103.2	102.8

HOG NO. 1884. (A.)

Hour.	Mar. 6, before injection.	Mar. 7, after injection.
	° *F.*	° *F.*
1 a.m.	102.2	102.6
2 a.m.	102.0	102.6
3 a.m.	102.4	102.0
4 a.m.	102.2	102.0
5 a.m.	102.0	102.4
6 a.m.	101.8	103.0
7 a.m.	101.6	102.8
8 a.m.	101.4	102.0
9 a.m.	102.8	102.8
10 a.m.	103.0	102.8
11 a.m.	103.0	102.8
12 m.	103.0	102.6
1 p.m.	102.8	102.0
2 p.m.	103.0	102.0
3 p.m.	103.0	102.4
4 p.m.	103.0	102.0
5 p.m.	103.0	102.6
6 p.m.	103.4	102.4
7 p.m.	103.0	102.4
8 p.m.	102.6	102.4
9 p.m.	102.4	102.2
10 p.m.	102.0	102.2
11 p.m.	[a] 102.2	102.4
12 p.m.	102.6	102.2

HOG NO. 1885. (A.)

Hour.	Mar. 6, before injection.	Mar. 7, after injection.
	° *F.*	° *F.*
1 a.m.	102.8	103.0
2 a.m.	102.4	102.6
3 a.m.	102.2	102.4
4 a.m.	101.8	102.8
5 a.m.	101.8	102.6
6 a.m.	101.2	102.8
7 a.m.	101.4	102.6
8 a.m.	102.0	103.2
9 a.m.	102.4	103.2
10 a.m.	103.0	103.0
11 a.m.	103.4	103.0
12 m.	103.0	102.8
1 p.m.	103.2	103.0
2 p.m.	103.0	103.0
3 p.m.	102.6	102.4
4 p.m.	103.2	102.4
5 p.m.	103.2	102.8
6 p.m.	102.8	102.6
7 p.m.	102.8	102.4
8 p.m.	102.4	102.2
9 p.m.	103.0	102.2
10 p.m.	103.0	102.2
11 p.m.	[a] 102.6	103.0
12 p.m.	102.8	102.8

HOG NO. 1886. (A.)

Hour.	Mar. 6, before injection.	Mar. 7, after injection.
	° *F.*	° *F.*
1 a.m.	102.2	101.8
2 a.m.	102.4	101.8
3 a.m.	102.4	101.8
4 a.m.	102.2	102.4
5 a.m.	102.2	102.0
6 a.m.	102.0	102.2
7 a.m.	102.0	101.8
8 a.m.	102.0	101.8
9 a.m.	102.4	102.2
10 a.m.	103.0	102.2
11 a.m.	103.8	102.0
12 m.	102.4	101.8
1 p.m.	102.2	101.8
2 p.m.	102.0	101.8
3 p.m.	102.4	102.0
4 p.m.	102.0	102.0
5 p.m.	102.4	102.0
6 p.m.	102.2	102.2
7 p.m.	102.4	102.4
8 p.m.	102.2	102.0
9 p.m.	102.4	102.0
10 p.m.	102.0	102.0
11 p.m.	[a] 101.6	101.8
12 p.m.	102.0	101.8

[a] Injected with ¼ c. c. of tuberculin at this hour.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1887. (A.)

Hour.	Mar. 6, before injection.	Mar. 7, after injection.
	°*F.*	°*F.*
1 a. m	104.2	103.2
2 a. m	104.0	103.4
3 a. m	104.0	103.6
4 a. m	104.0	103.8
5 a. m	103.8	103.6
6 a. m	103.8	103.8
7 a. m	103.6	103.8
8 a. m	103.8	103.6
9 a. m	103.6	103.6
10 a. m	103.8	103.6
11 a. m	103.6	103.6
12 m	103.4	103.4
1 p. m	103.8	103.4
2 p. m	103.6	103.0
3 p. m	103.6	103.0
4 p. m	103.6	103.0
5 p. m	103.2	103.2
6 p. m	103.6	103.6
7 p. m	103.4	103.6
8 p. m	103.6	103.2
9 p. m	103.4	103.6
10 p. m	103.0	103.4
11 p. m	a 103.8	103.0
12 p. m	103.4	103.0

HOG NO. 1888. (A.)

Hour.	Mar. 6, before injection.	Mar. 7, after injection.
	°*F.*	°*F.*
1 a. m	102.4	102.6
2 a. m	102.6	102.4
3 a. m	102.0	102.4
4 a. m	102.2	103.0
5 a. m	102.2	103.0
6 a. m	102.2	103.0
7 a. m	102.2	103.0
8 a. m	103.0	103.0
9 a. m	102.4	103.4
10 a. m	103.0	103.2
11 a. m	103.6	103.6
12 m	104.0	103.0
1 p. m	103.4	102.8
2 p. m	102.8	102.4
3 p. m	102.6	103.2
4 p. m	103.0	102.8
5 p. m	102.6	102.8
6 p. m	102.8	103.0
7 p. m	103.0	102.8
8 p. m	102.8	102.4
9 p. m	102.4	102.0
10 p. m	102.6	102.0
11 p. m	a 101.4	102.4
12 p. m	103.4	102.2

HOG NO. 1889. (A.)

Hour.	Mar. 6, before injection.	Mar. 7, after injection.
	°*F.*	°*F.*
1 a. m	103.8	103.6
2 a. m	103.8	103.2
3 a. m	103.8	103.6
4 a. m	103.6	103.2
5 a. m	103.8	102.6
6 a. m	103.8	103.6
7 a. m	103.6	103.4
8 a. m	103.4	103.4
9 a. m	103.6	103.2
10 a. m	103.6	103.4
11 a. m	103.6	103.0
12 m	103.4	103.0
1 p. m	103.4	103.0
2 p. m	103.4	103.0
3 p. m	103.4	103.8
4 p. m	102.2	103.0
5 p. m	103.2	103.0
6 p. m	103.4	103.2
7 p. m	103.8	103.8
8 p. m	103.4	103.6
9 p. m	104.0	103.4
10 p. m	103.6	103.2
11 p. m	a 104.0	103.2
12 p. m	103.4	103.2

HOG NO. 1891. (A.)

Hour.	Mar. 6, before injection.	Mar. 7, after injection.
	°*F.*	°*F.*
1 a. m	102.6	102.4
2 a. m	103.0	101.6
3 a. m	102.2	102.4
4 a. m	102.0	102.4
5 a. m	101.8	102.2
6 a. m	101.8	102.4
7 a. m	101.6	102.4
8 a. m	102.8	102.2
9 a. m	102.8	102.2
10 a. m	103.0	102.6
11 a. m	103.4	102.8
12 m	102.8	102 6
1 p. m	103.0	102.2
2 p. m	102.6	102.4
3 p. m	102.6	102.0
4 p. m	102.4	102.2
5 p. m	103.2	102.6
6 p. m	103.0	102.6
7 p. m	102.6	102.2
8 p. m	103.6	102.0
9 p. m	102.0	101.6
10 p. m	102.2	101.8
11 p. m	a 102.6	102.0
12 p. m	104.0	101.8

a Injected with ½ c. c. of tuberculin at this hour.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1751. (T.)

Hour.	Mar. 20, before injection.	Mar. 21, after injection.
	°*F.*	°*F.*
1 a. m	101.6	102.4
2 a. m	101.8	102.4
3 a. m	101.6	102.6
4 a. m	101.2	102.6
5 a. m	101.4	102.8
6 a. m	101.0	103.2
7 a. m	101.2	104.0
8 a. m	101.2	105.4
9 a. m	101.2	104.6
10 a. m	101.6	103.6
11 a. m	101.8	106.2
12 m	102.2	105.2
1 p. m	102.2	105.2
2 p. m	102.0	106.0
3 p. m	102.4	106.0
4 p. m	102.6	105.8
5 p. m	102.6	106.2
6 p. m	102.0	106.0
7 p. m	102.2	105.8
8 p. m	102.4	104.4
9 p. m	102.6	104.8
10 p. m	102.4	105.2
11 p. m	*a* 102.6	104.4
12 p. m	102.6	104.8

HOG NO. 1755. (T.)

Hour.	Mar. 20, before injection.	Mar. 21, after injection.
	°*F.*	°*F.*
1 a. m	100.6	103.8
2 a. m	102.0	103.8
3 a. m	102.0	103.8
4 a. m	101.6	103.8
5 a. m	101.2	104.0
6 a. m	101.2	104.0
7 a. m	101.2	104.6
8 a. m	102.4	104.6
9 a. m	103.0	105.2
10 a. m	103.0	105.2
11 a. m	103.0	105.0
12 m	102.6	104.6
1 p. m	103.0	104.4
2 p. m	103.0	105.0
3 p. m	102.6	104.2
4 p. m	102.6	104.4
5 p. m	103.0	103.8
6 p. m	103.2	103.8
7 p. m	102.8	104.2
8 p. m	102.6	104.0
9 p. m	102.2	103.8
10 p. m	102.2	103.0
11 p. m	*a* 102.4	104.2
12 p. m	102.8	104.0

HOG NO. 1754. (T.)

Hour.	Mar. 20, before injection.	Mar. 21, after injection.
	°*F.*	°*F.*
1 a. m	101.4	102.0
2 a. m	100.2	101.6
3 a. m	101.2	102.4
4 a. m	101.4	102.6
5 a. m	100.4	102.6
6 a. m	101.2	102.0
7 a. m	101.2	101.0
8 a. m	101.6	101.6
9 a. m	100.2	102.0
10 a. m	101.0	103.4
11 a. m	101.6	103.8
12 m	101.8	103.0
1 p. m	101.6	102.6
2 p. m	101.8	102.8
3 p. m	101.8	102.4
4 p. m	102.0	102.4
5 p. m	102.0	103.6
6 p. m	102.6	102.8
7 p. m	102.6	103.6
8 p. m	102.6	103.0
9 p. m	102.4	103.0
10 p. m	102.4	102.8
11 p. m	*a* 101.6	103.0
12 p. m	102.0	103.0

HOG NO. 1772. (T.)

Hour.	Mar. 20, before injection.	Mar. 21, after injection.
	°*F.*	°*F.*
1 a. m	101.8	101.6
2 a. m	101.0	101.8
3 a. m	100.6	101.8
4 a. m	101.4	101.6
5 a. m	101.2	103.0
6 a. m	101.2	102.0
7 a. m	101.4	104.2
8 a. m	100.4	104.0
9 a. m	101.0	104.2
10 a. m	101.2	105.2
11 a. m	101.4	105.6
12 m	101.0	104.6
1 p. m	102.0	104.6
2 p. m	101.6	105.0
3 p. m	101.4	105.2
4 p. m	102.4	104.6
5 p. m	102.4	105.4
6 p. m	101.8	105.0
7 p. m	102.0	104.8
8 p. m	102.4	103.6
9 p. m	102.2	103.8
10 p. m	102.2	103.2
11 p. m	*a* 102.2	102.8
12 p. m	101.6	103.0

a Injected with ¼ c. c. of tuberculin at this hour.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1783. (T.)

Hour.	Mar. 20, before injection.	Mar. 21, after injection.
	° *F.*	° *F.*
1 a. m	102.6	101.0
2 a. m	101.8	100.8
3 a. m	101.2	101.4
4 a. m	102.6	102.2
5 a. m	101.2	103.0
6 a. m	102.0	103.2
7 a. m	101.2	102.6
8 a. m	101.2	105.0
9 a. m	102.0	105.2
10 a. m	102.0	103.6
11 a. m	102.0	104.8
12 m	102.0	103.8
1 p. m	102.0	104.0
2 p. m	102.0	104.8
3 p. m	101.8	104.6
4 p. m	101.8	105.0
5 p. m	101.6	105.6
6 p. m	101.4	104.6
7 p. m	101.6	104.8
8 p. m	101.2	104.4
9 p. m	101.2	104.0
10 p. m	100.8	103.2
11 p. m	*a* 101.8	103.6
12 p. m	101.0	103.6

HOG NO. 1798. (T.)

Hour.	Mar. 20, before injection.	Mar. 21, after injection.
	° *F.*	° *F.*
1 a. m	100.8	102.4
2 a. m	100.8	103.4
3 a. m	101.2	103.6
4 a. m	101.4	104.4
5 a. m	101.2	105.6
6 a. m	100.4	106.0
7 a. m	100.2	106.0
8 a. m	103.0	106.0
9 a. m	103.2	106.0
10 a. m	103.0	106.0
11 a. m	103.0	105.4
12 m	103.0	105.4
1 p. m	103.0	104.0
2 p. m	103.2	104.6
3 p. m	103.0	104.6
4 p. m	103.0	104.2
5 p. m	103.2	104.0
6 p. m	102.6	104.0
7 p. m	103.0	104.0
8 p. m	103.0	103.6
9 p. m	102.4	103.4
10 p. m	102.2	103.0
11 p. m	*a* 102.8	103.8
12 p. m	102.6	103.4

HOG NO. 1790. (T.)

Hour.	Mar. 20, before injection.	Mar. 21, after injection.
	° *F.*	° *F.*
1 a. m	100.6	101.4
2 a. m	100.0	101.4
3 a. m	100.2	101.6
4 a. m	100.2	101.2
5 a. m	100.0	100.6
6 a. m	100.0	100.4
7 a. m	100.0	100.6
8 a. m	99.0	100.2
9 a. m	101.0	100.6
10 a. m	101.2	100.4
11 a. m	101.2	101.2
12 m	101.4	100.8
1 p. m	101.2	101.0
2 p. m	101.2	102.0
3 p. m	101.2	102.2
4 p. m	101.0	102.2
5 p. m	101.6	102.8
6 p. m	101.6	103.0
7 p. m	101.4	102.4
8 p. m	102.0	103.0
9 p. m	102.0	102.8
10 p. m	101.8	102.8
11 p. m	*a* 101.4	103.0
12 p. m	101.6	102.8

HOG NO. 1801. (T.)

Hour.	Mar. 20, before injection.	Mar. 21, after injection.
	° *F.*	° *F.*
1 a. m	101.8	100.6
2 a. m	101.2	100.6
3 a. m	101.6	100.4
4 a. m	101.6	100.6
5 a. m	101.4	100.0
6 a. m	101.2	101.2
7 a. m	101.2	102.0
8 a. m	101.4	103.0
9 a. m	102.2	105.0
10 a. m	102.0	105.0
11 a. m	102.0	105.0
12 m	101.6	104.8
1 p. m	101.8	105.2
2 p. m	101.0	105.0
3 p. m	101.2	105.0
4 p. m	101.4	105.0
5 p. m	102.0	105.6
6 p. m	102.2	104.8
7 p. m	102.6	104.2
8 p. m	102.2	104.2
9 p. m	101.8	103.8
10 p. m	101.8	103.8
11 p. m	*a* 101.2	103.2
12 p. m	100.6	103.2

a Injected with ⅛ c. c. of tuberculin at this hour.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1808. (T.)			HOG NO. 1809. (T.)		
Hour.	Mar. 20, before injection.	Mar. 21, after injection.	Hour.	Mar. 20, before injection.	Mar. 21, after injection.
	° F.	° F.		° F.	° F.
1 a. m	101.6	104.2	1 a. m	101.2	102.4
2 a. m	100.8	105.0	2 a. m	101.2	102.4
3 a. m	100.8	105.2	3 a. m	101.4	102.6
4 a. m	101.2	105.2	4 a. m	101.2	102.8
5 a. m	101.4	106.0	5 a. m	101.2	102.4
6 a. m	102.0	106.2	6 a. m	101.0	103.2
7 a. m	101.2	106.2	7 a. m	101.0	104.6
8 a. m	102.0	106.0	8 a. m	101.8	104.2
9 a. m	103.0	106.0	9 a. m	102.8	105.6
10 a. m	102.8	106.0	10 a. m	102.6	106.2
11 a. m	103.0	105.6	11 a. m	102.2	105.2
12 m	103.0	105.6	12 m	102.4	106.2
1 p. m	103.0	103.6	1 p. m	102.2	105.6
2 p. m	102.8	104.2	2 p. m	102.4	106.2
3 p. m	102.2	104.4	3 p. m	102.4	106.4
4 p. m	102.8	104.6	4 p. m	102.8	106.8
5 p. m	103.2	106.0	5 p. m	102.6	106.4
6 p. m	103.6	105.4	6 p. m	102.2	106.0
7 p. m	103.6	105.0	7 p. m	102.4	105.8
8 p. m	104.0	104.8	8 p. m	102.6	105.2
9 p. m	104.2	105.0	9 p. m	102.4	105.2
10 p. m	105.0	104.8	10 p. m	102.4	105.0
11 p. m	[a]104.0	105.4	11 p. m	[a]102.2	104.8
12 p. m	104.6	105.0	12 p. m	102.0	105.0
HOG NO. 1805. (T.)			HOG NO. 1811. (T.)		
	° F.	° F.		° F.	° F.
1 a. m	101.6	101.4	1 a. m	102.0	102.6
2 a. m	101.0	101.6	2 a. m	101.8	102.6
3 a. m	100.2	101.8	3 a. m	102.0	103.0
4 a. m	100.4	101.6	4 a. m	102.0	103.8
5 a. m	100.2	102.0	5 a. m	101.2	105.0
6 a. m	100.0	102.6	6 a. m	101.2	106.0
7 a. m	100.4	103.4	7 a. m	102.4	106.4
8 a. m	101.2	103.0	8 a. m	102.6	106.4
9 a. m	101.8	103.8	9 a. m	103.0	106.2
10 a. m	101.6	103.8	10 a. m	103.2	106.4
11 a. m	101.8	104.8	11 a. m	102.6	105.6
12 m	102.0	104.6	12 m	103.0	105.6
1 p. m	102.2	105.0	1 p. m	103.2	105.6
2 p. m	102.4	105.2	2 p. m	103.0	105.6
3 p. m	102.0	104.6	3 p. m	102.6	105.0
4 p. m	102.0	104.6	4 p. m	103.2	105.0
5 p. m	102.2	104.4	5 p. m	102.4	105.2
6 p. m	102.2	104.4	6 p. m	102.6	104.2
7 p. m	101.8	104.2	7 p. m	102.6	104.6
8 p. m	101.6	103.8	8 p. m	102.4	105.0
9 p. m	101.8	103.2	9 p. m	102.4	104.4
10 p. m	102.2	102.8	10 p. m	102.8	104.6
11 p. m	[a]102.2	103.8	11 p. m	[a]102.2	104.0
12 p. m	101.4	103.6	12 p. m	102.2	104.2

[a] Injected with ½ c. c. of tuberculin at this hour.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1383. (A.)

Hour.	Apr. 3, before injection.	Apr. 4, after injection.
	°F.	°F.
1 a. m	101.6	101.6
2 a. m	101.2	101.6
3 a. m	101.2	101.6
4 a. m	101.0	101.2
5 a. m	100.8	101.0
6 a. m	100.6	100.8
7 a. m	101.2	100.4
8 a. m	100.6	100.6
9 a. m	101.4	101.2
10 a. m	101.0	100.6
11 a. m	101.0	100.6
12 m	100.0	100.4
1 p. m	100.4	100.6
2 p. m	101.0	100.6
3 p. m	101.0	101.0
4 p. m	101.0	101.2
5 p. m	101.8	101.4
6 p. m	101.4	101.2
7 p. m	101.4	101.4
8 p. m	101.6	101.2
9 p. m	101.6	101.2
10 p. m	101.2	101.4
11 p. m	[a] 101.4	100.8
12 p. m	101.6	101.0

HOG NO. 1385. (A.)

Hour.	April 3, before injection.	April 4, after injection.
	°F.	°F.
1 a. m	102.0	102.4
2 a. m	101.8	102.2
3 a. m	102.0	102.2
4 a. m	101.8	102.0
5 a. m	102.0	102.6
6 a. m	102.4	102.2
7 a. m	102.2	102.0
8 a. m	102.4	101.6
9 a. m	102.8	102.0
10 a. m	102.0	101.6
11 a. m	103.0	101.6
12 m	102.2	101.6
1 p. m	102.2	101.6
2 p. m	102.6	101.8
3 p. m	102.2	101.6
4 p. m	102.0	101.6
5 p. m	102.2	102.2
6 p. m	102.0	102.0
7 p. m	101.8	102.4
8 p. m	101.0	102.2
9 p. m	101.8	102.0
10 p. m	101.8	102.0
11 p. m	[a] 102.0	102.0
12 p. m	102.2	101.8

HOG NO. 1384. (A.)

Hour.	Apr. 3, before injection.	Apr. 4, after injection.
	°F.	°F.
1 a. m	101.8	101.8
2 a. m	101.8	102.0
3 a. m	101.8	102.2
4 a. m	101.8	102.2
5 a. m	102.0	101.8
6 a. m	102.0	102.2
7 a. m	102.4	102.4
8 a. m	101.8	101.6
9 a. m	102.0	102.0
10 a. m	102.0	101.8
11 a. m	102.0	101.6
12 m	101.6	101.4
1 p. m	101.8	101.6
2 p. m	101.2	101.4
3 p. m	101.8	101.2
4 p. m	101.8	101.4
5 p. m	101.6	101.2
6 p. m	102.0	101.4
7 p. m	101.6	101.8
8 p. m	102.2	101.4
9 p. m	101.8	101.0
10 p. m	101.8	101.0
11 p. m	[a] 102.0	101.4
12 p. m	102.0	101.2

HOG NO. 1399. (A.)

Hour.	April 3, before injection.	April 4, after injection.
	°F.	°F.
1 a. m	100.2	100.6
2 a. m	101.6	100.6
3 a. m	101.0	100.6
4 a. m	101.2	100.4
5 a. m	101.4	100.6
6 a. m	100.8	100.4
7 a. m	101.2	101.0
8 a. m	101.2	101.4
9 a. m	101.0	100.4
10 a. m	101.6	101.0
11 a. m	101.4	101.0
12 m	101.2	101.0
1 p. m	101.2	100.0
2 p. m	101.0	100.0
3 p. m	101.0	101.2
4 p. m	101.4	101.0
5 p. m	101.2	101.2
6 p. m	102.0	101.4
7 p. m	101.0	102.0
8 p. m	100.8	100.8
9 p. m	101.0	100.8
10 p. m	100.4	100.6
11 p. m	[a] 100.4	100.8
12 p. m	100.8	101.0

[a] Injected with 1 c. c. of tuberculin at this hour.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1446. (A.)

Hour.	Apr. 3, before injection.	Apr. 4, after injection.
	°F.	°F.
1 a.m	100.8	101.0
2 a.m	100.8	101.4
3 a.m	100.8	101.4
4 a.m	100.6	101.2
5 a.m	100.4	101.6
6 a.m	100.4	101.6
7 a.m	100.2	102.0
8 a.m	100.6	101.2
9 a.m	101.8	101.2
10 a.m	101.6	101.2
11 a.m	101.8	100.8
12 m	101.8	101.6
1 p.m	101.6	101.2
2 p.m	101.6	101.0
3 p.m	101.4	101.4
4 p.m	102.0	101.4
5 p.m	101.6	102.0
6 p.m	101.4	102.0
7 p.m	101.2	101.0
8 p.m	100.8	101.2
9 p.m	101.0	101.2
10 p.m	101.2	101.2
11 p.m	[a] 100.8	101.4
12 p.m	100.8	101.2

HOG NO. 1895. (H.)

Hour.	Apr. 3, before injection.	Apr. 4, after injection.
	°F.	°F.
1 a.m	101.8	102.6
2 a.m	102.0	102.6
3 a.m	102.0	102.8
4 a.m	102.0	102.4
5 a.m	101.8	103.2
6 a.m	102.0	104.0
7 a.m	102.0	104.0
8 a.m	102.4	103.4
9 a.m	102.2	103.4
10 a.m	102.2	103.8
11 a.m	102.2	103.8
12 m	102.4	103.4
1 p.m	101.8	103.4
2 p.m	102.2	102.6
3 p.m	102.2	102.8
4 p.m	101.6	103.2
5 p.m	102.0	103.0
6 p.m	102.2	103.4
7 p.m	101.8	102.8
8 p.m	102.6	103.0
9 p.m	102.6	103.0
10 p.m	102.2	102.6
11 p.m	[b] 102.0	102.6
12 p.m	102.0	102.6

HOG NO. 1527. (A.)

Hour.	Apr. 3, before injection.	Apr. 4, after injection.
	°F.	°F.
1 a.m	100.4	101.0
2 a.m	101.4	101.0
3 a.m	101.2	101.0
4 a.m	100.8	100.8
5 a.m	100.8	101.2
6 a.m	100.0	101.4
7 a.m	100.2	101.4
8 a.m	101.4	101.0
9 a.m	101.4	100.4
10 a.m	102.0	100.4
11 a.m	101.6	101.0
12 m	100.8	100.8
1 p.m	100.8	100.8
2 p.m	101.6	100.6
3 p.m	101.2	100.4
4 p.m	101.4	100.6
5 p.m	102.6	101.0
6 p.m	102.0	101.4
7 p.m	101.6	101.4
8 p.m	101.8	100.8
9 p.m	101.2	101.2
10 p.m	101.4	101.2
11 p.m	[b] 101.0	100.8
12 p.m	100.8	100.8

HOG NO. 1896. (A.)

Hour.	Apr. 3, before injection.	Apr. 4, after injection.
	°F.	°F.
1 a.m	101.2	100.6
2 a.m	101.0	100.4
3 a.m	100.6	100.2
4 a.m	100.8	100.2
5 a.m	100.8	100.6
6 a.m	101.2	100.8
7 a.m	100.8	101.2
8 a.m	100.8	101.4
9 a.m	101.0	101.4
10 a.m	101.6	101.0
11 a.m	101.8	101.4
12 m	101.8	101.0
1 p.m	101.4	101.0
2 p.m	100.8	100.4
3 p.m	101.2	100.6
4 p.m	101.6	101.6
5 p.m	102.0	101.4
6 p.m	101.8	101.6
7 p.m	102.2	100.4
8 p.m	102.0	101.0
9 p.m	101.0	100.6
10 p.m	101.6	100.6
11 p.m	[b] 101.2	101.2
12 p.m	100.6	101.0

[a] Injected with 1 c. c. of tuberculin at this hour.

[b] Injected with ½ c. c. of tuberculin at this hour.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1897. (A.)			HOG NO. 1855. (T.)[b]		
Hour.	Apr. 3, before injection.	Apr. 4, after injection.	Hour.	Apr. 3, before injection.	Apr. 4, after injection.
	°F.	°F.		°F.	°F.
1 a.m.	101.8	103.0	1 a.m.	102.0	103.6
2 a.m.	102.0	102.8	2 a.m.	102.0	103.8
3 a.m.	101.6	102.8	3 a.m.	101.8	103.6
4 a.m.	101.6	102.6	4 a.m.	101.8	103.8
5 a.m.	101.4	102.4	5 a.m.	102.0	104.6
6 a.m.	101.0	102.0	6 a.m.	102.2	104.6
7 a.m.	101.6	102.6	7 a.m.	102.2	104.2
8 a.m.	101.6	102.4	8 a.m.	102.0	105.0
9 a.m.	102.0	102.8	9 a.m.	102.4	105.2
10 a.m.	101.8	103.0	10 a.m.	102.4	105.2
11 a.m.	102.0	103.2	11 a.m.	103.0	106.2
12 m.	102.4	102.4	12 m.	102.2	105.6
1 p.m.	102.4	102.8	1 p.m.	102.2	105.8
2 p.m.	102.2	102.4	2 p.m.	102.4	106.0
3 p.m.	102.2	102.4	3 p.m.	102.4	106.0
4 p.m.	102.2	103.0	4 p.m.	102.0	106.4
5 p.m.	102.6	102.8	5 p.m.	103.0	106.2
6 p.m.	102.6	102.8	6 p.m.	102.8	106.2
7 p.m.	103.0	102.4	7 p.m.	103.4	106.6
8 p.m.	102.6	102.8	8 p.m.	103.8	106.4
9 p.m.	102.2	102.2	9 p.m.	103.6	106.2
10 p.m.	102.4	102.0	10 p.m.	103.8	106.4
11 p.m.	[a] 102.4	102.0	11 p.m.	[a] 103.4	106.2
12 p.m.	102.6	102.2	12 p.m.	103.0	106.2
HOG NO. 1854. (T.)[b]			HOG NO. 1856. (T.)[b]		
	°F.	°F.		°F.	°F.
1 a.m.	103.8	103.4	1 a.m.	103.8	103.4
2 a.m.	103.2	103.4	2 a.m.	104.0	103.6
3 a.m.	103.2	104.0	3 a.m.	103.8	103.4
4 a.m.	103.2	104.0	4 a.m.	103.8	103.4
5 a.m.	103.4	105.0	5 a.m.	103.6	103.4
6 a.m.	103.6	105.6	6 a.m.	103.6	103.8
7 a.m.	103.4	106.0	7 a.m.	103.8	103.4
8 a.m.	103.2	105.6	8 a.m.	103.0	104.0
9 a.m.	102.2	105.0	9 a.m.	104.0	104.2
10 a.m.	103.2	106.0	10 a.m.	103.8	103.8
11 a.m.	103.0	106.2	11 a.m.	102.8	104.2
12 m.	103.4	106.4	12 m.	103.2	104.8
1 p.m.	103.0	106.0	1 p.m.	103.2	104.8
2 p.m.	103.0	106.0	2 p.m.	103.0	105.0
3 p.m.	103.0	105.8	3 p.m.	103.2	105.0
4 p.m.	103.0	105.6	4 p.m.	103.0	104.6
5 p.m.	103.2	106.4	5 p.m.	104.4	105.4
6 p.m.	103.4	106.0	6 p.m.	103.8	105.2
7 p.m.	103.4	106.0	7 p.m.	103.8	105.0
8 p.m.	103.0	105.0	8 p.m.	103.4	106.0
9 p.m.	103.0	105.0	9 p.m.	103.6	105.2
10 p.m.	102.6	104.4	10 p.m.	103.6	105.4
11 p.m.	[a] 103.0	104.4	11 p.m.	[a] 103.8	105.4
12 p.m.	103.0	104.2	12 p.m.	103.8	105.2

[a] Injected with ½ c. c. of tuberculin at this hour. [b] Second test.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1846. (T.)[a]			HOG NO. 1849. (T.)[a]		
Hour.	Apr. 3, before injection.	Apr. 4, after injection.	Hour.	Apr. 3, before injection.	Apr. 4, after injection.
	° *F.*	° *F.*		° *F.*	° *F.*
1 a. m.	101.8	101.6	1 a. m.	101.4	101.6
2 a. m.	101.8	102.0	2 a. m.	102.4	102.0
3 a. m.	101.6	102.0	3 a. m.	102.4	102.4
4 a. m.	101.8	101.8	4 a. m.	102.0	102.2
5 a. m.	102.2	101.6	5 a. m.	102.0	102.2
6 a. m.	102.2	101.2	6 a. m.	101.6	102.6
7 a. m.	102.2	101.6	7 a. m.	101.8	103.0
8 a. m.	102.4	102.2	8 a. m.	101.8	103.6
9 a. m.	101.8	103.4	9 a. m.	102.6	103.8
10 a. m.	102.0	104.2	10 a. m.	103.2	103.8
11 a. m.	101.8	105.2	11 a. m.	103.0	104.2
12 m.	101.8	105.0	12 m.	102.6	104.6
1 p. m.	101.0	105.4	1 p. m.	102.4	105.0
2 p. m.	101.4	105.4	2 p. m.	102.8	105.0
3 p. m.	101.2	105.6	3 p. m.	102.4	104.8
4 p. m.	101.4	105.6	4 p. m.	102.6	104.8
5 p. m.	102.0	106.0	5 p. m.	103.4	105.4
6 p. m.	101.8	106.0	6 p. m.	103.0	105.6
7 p. m.	102.0	106.4	7 p. m.	102.2	105.4
8 p. m.	102.0	106.4	8 p. m.	102.2	105.0
9 p. m.	101.8	106.2	9 p. m.	102.2	105.2
10 p. m.	102.0	106.0	10 p. m.	102.4	105.2
11 p. m.	[b] 102.2	105.8	11 p. m.	[b] 102.2	105.2
12 p. m.	101.6	106.0	12 p. m.	102.0	105.2

HOG NO. 1848. (T.)[a]			HOG NO. 1898. (A.)[a]		
	° *F.*	° *F.*		° *F.*	° *F.*
1 a. m.	102.6	103.0	1 a. m	100.8	102.8
2 a. m.	102.8	103.2	2 a. m	101.0	103.0
3 a. m.	103.0	103.4	3 a. m	101.0	103.4
4 a. m.	102.8	103.0	4 a. m	100.8	102.6
5 a. m.	103.0	103.0	5 a. m	101.0	102.2
6 a. m.	103.0	102.8	6 a. m	101.6	103.0
7 a. m.	103.2	102.4	7 a. m	101.6	102.6
8 a. m.	103.0	103.0	8 a. m	102.4	103.0
9 a. m.	102.4	103.0	9 a. m	102.8	102.0
10 a. m.	102.6	103.4	10 a. m	102.0	102.4
11 a. m.	102.6	103.0	11 a. m	102.2	102.6
12 m.	103.0	103.0	12 m.	102.0	102.4
1 p. m.	102.4	103.0	1 p. m	101.8	102.4
2 p. m.	102.4	103.6	2 p. m	102.4	102.4
3 p. m.	102.4	103.4	3 p. m	102.6	102.0
4 p. m.	103.0	104.2	4 p. m	103.0	103.0
5 p. m.	103.4	105.6	5 p. m	103.2	103.2
6 p. m.	103.4	105.0	6 p. m	103.0	103.0
7 p. m.	103.6	105.6	7 p. m	103.0	103.4
8 p. m.	103.0	105.4	8 p. m	103.0	103.2
9 p. m.	103.4	105.0	9 p. m	103.2	103.0
10 p. m.	102.6	105.0	10 p. m	103.0	102.6
11 p. m.	[b] 102.6	105.0	11 p. m	[b] 103.0	102.4
12 p. m.	103.0	104.8	12 p. m	103.0	102.6

[a] Second test.

[b] Injected with ½ c. c. of tuberculin at this hour.

Table showing the temperature of hogs before and after injection—Continued.

HOG NO. 1838. (H.)[a]

Hour.	Apr. 3, before injection.	Apr. 4, after injection.
	° *F.*	° *F.*
1 a. m	101.0	100.6
2 a. m	100.8	100.6
3 a. m	100.8	100.6
4 a. m	100.0	100.4
5 a. m	100.2	100.0
6 a. m	100.0	100.0
7 a. m	100.0	100.2
8 a. m	99.6	100.6
9 a. m	102.0	101.0
10 a. m	102.0	101.0
11 a. m	100.4	101.6
12 m	100.6	101.0
1 p. m	100.0	101.0
2 p. m	100.6	101.2
3 p. m	101.0	101.0
4 p. m	101.4	100.6
5 p. m	102.2	100.8
6 p. m	101.2	101.0
7 p. m	101.0	100.8
8 p. m	100.8	100.8
9 p. m	100.8	101.2
10 p. m	100.8	100.8
11 p. m	[b] 100.6	100.6
12 p. m	100.6	100.8

HOG NO. 1843. (T.)[a]

Hour.	Apr. 11, before injection.	Apr. 12, after injection.
	° *F.*	° *F.*
1 a. m	101.0	101.0
2 a. m	101.2	101.0
3 a. m	101.6	101.0
4 a. m	101.0	101.0
5 a. m	101.0	101.8
6 a. m	100.8	102.4
7 a. m	101.6	103.0
8 a. m	101.4	103.6
9 a. m	100.4	105.0
10 a. m	102.0	104.2
11 a. m	101.6	104.4
12 m	101.0	104.0
1 p. m	100.0	103.6
2 p. m	100.8	104.0
3 p. m	101.0	104.0
4 p. m	101.0	104.0
5 p. m	101.6	104.2
6 p. m	101.6	103.6
7 p. m	101.6	102.6
8 p. m	102.0	102.6
9 p. m	101.2	102.6
10 p. m	101.2	102.2
11 p. m	[b] 101.8	102.2
12 p. m	101.2	102.2

HOG NO. 1840. (H.)[a]

Hour.	Apr. 3, before injection.	Apr. 4, after injection.
	° *F.*	° *F.*
1 a. m	101.8	101.8
2 a. m	102.0	101.4
3 a. m	102.2	101.6
4 a. m	102.2	101.6
5 a. m	102.2	101.6
6 a. m	102.0	101.8
7 a. m	102.0	101.4
8 a. m	102.0	101.4
9 a. m	102.0	103.0
10 a. m	102.0	102.4
11 a. m	101.8	102.0
12 m	101.8	102.2
1 p. m	102.0	102.2
2 p. m	102.4	102.4
3 p. m	102.0	102.4
4 p. m	102.6	102.2
5 p. m	102.6	102.4
6 p. m	102.6	102.4
7 p. m	102.2	102.8
8 p. m	102.6	102.2
9 p. m	102.0	101.8
10 p. m	102.0	102.0
11 p. m	[b] 101.6	101.6
12 p. m	101.8	101.8

HOG NO. 1844. (T.)[a]

Hour.	Apr. 11, before injection.	Apr. 12, after injection.
	° *F.*	° *F.*
1 a. m	103.6	103.6
2 a. m	103.8	103.4
3 a. m	103.8	103.6
4 a. m	103.8	104.0
5 a. m	103.6	104.2
6 a. m	103.2	104.6
7 a. m	103.6	105.6
8 a. m	103.2	106.0
9 a. m	103.2	106.6
10 a. m	103.6	106.4
11 a. m	103.0	106.6
12 m	102.2	106.6
1 p. m	102.0	106.4
2 p. m	102.8	106.6
3 p. m	103.0	106.4
4 p. m	103.0	106.0
5 p. m	103.2	106.2
6 p. m	104.0	106.2
7 p. m	103.6	106.2
8 p. m	103.4	106.0
9 p. m	103.4	105.2
10 p. m	103.0	104.8
11 p. m	[b] 103.4	104.2
12 p. m	103.4	104.0

[a] Second test.

[b] Injected with $\frac{1}{8}$ c. c. of tuberculin at this hour.

Autopsy Records.

HOGS FED TUBERCULOUS MILK.

Hog No. 1853.—Found dead the morning of February 21, 1906. General condition excellent; fat. During the tuberculin test, both before and after the injection of tuberculin, the respiration was accompanied by a snoring sound and the number of respirations was greater than normal. Glands at the angles of the jaws (submaxillary) are enlarged, congested, and sprinkled with tuberculous foci. The gland back of pharynx (post-pharangeal) on left side is in the same condition. Other glands in region of throat are unaffected. The superficial inguinal glands on left side are ten times as large as those on the right and are entirely congested, but show no tuberculous lesions. (The tuberculin injection was made in the thigh near the enlarged glands.) The prepectoral gland directly in front of the trachea outside of the thorax and the corresponding glands just inside of the thorax are enlarged and sprinkled with foci of tuberculosis. Mediastinal and bronchial glands are greatly enlarged and contain cheesy material, which is beginning to soften. Lung is adherent to chest walls, heart, and diaphragm, and the different lobes to each other; the entire organ is thickly sprinkled with large tuberculous masses; the medium lobes are entirely cheesy, and at least one-half of the remainder of the lung is in the same condition. The portal glands are enlarged and necrotic. The liver is sprinkled with numerous tuberculous foci, from 1 to 3 mm. in diameter. The spleen contains a few tuberculous foci, from 1 to 3 mm. in diameter. The glands at the curvature of the stomach are enlarged and completely tuberculous. Only one mesenteric gland was found to contain lesions of tuberculosis.

Hog No. 1854.—Killed April 7, 1906. General condition excellent; fat. Right submaxillary gland is greatly enlarged, diameter about 4 cm., and completely tuberculous. Left prescapular gland contains a few tuberculous foci. The pulmonary pleura is greatly roughened and thickened and contains a number of tubercles, each about 5 mm. in diameter. The costal pleura and the pulmonary surface of the diaphragm contain a number of small tubercles from 1 to 5 mm. in diameter. The left cephalic lobe of the lung is tuberculous, and the other lobes are sprinkled thickly with tuberculous masses from 1 mm. to 1 cm. in diameter. The bronchial glands are studded with minute necrotic foci. The liver and spleen are sprinkled with numerous tuberculous foci from 1 to 3 mm. in diameter. Portal and gastric glands (glands at the curvature of the stomach) contain minute foci of tuberculosis. Minute tuberculous lesions found in three or four mesenteric glands.

Hog No. 1855.—Killed April 7, 1906. General condition excellent; fat. The submaxillary glands on both sides have a diameter from 4 to 5 cm., and are completely tuberculous. The prepectoral glands are enlarged and contain tuberculous foci. The lung is uniformly sprinkled with numerous tuberculous foci from 1 to 3 mm. in diameter. Both right and left bronchial glands contain small foci of tuberculosis. The liver has an even sprinkling of a small number of minute tuberculous foci, and the spleen is in the same condition. Gastro-hepatic chain of lymph glands contains tuberculous lesions. One mesenteric gland shows a tuberculous focus 2 mm. in diameter.

Hog No. 1856.—Killed April 7, 1906. General condition excellent. The submaxillary lymph glands on both sides are greatly enlarged and tuberculous. The lung is sprinkled uniformly with innumerable very minute, almost microscopic, and a few larger, tuberculous foci. The bronchial glands are somewhat enlarged, but show no tuberculous lesions. Two mesenteric glands contain each a tuberculous focus about 5 mm. in diameter.

Hog No. 1857.—Killed February 26, 1906. General condition excellent; fat. The right submaxillary gland is enlarged and contains a necrotic focus about 5 mm. in

diameter. About 1 out of every 3 mesenteric glands contains minute tuberculous foci.

Hog No. 1858.—Killed February 26, 1906. General condition excellent; fat. No lesions of disease found on autopsy.

Hog No. 1845.—Killed February 26, 1906. General condition excellent; fat. The submaxillary and prescapular glands on both sides are sprinkled with minute tuberculous foci. The superficial inguinal glands on both sides are greatly enlarged, edematous, and sprinkled with innumerable small foci of tuberculosis. Lung adherent to the chest wall and to the diaphragm, and the various lobes to each other. The two medium and the azygos lobes are completely tuberculous, and the principal lobes are thickly sprinkled with centers of tuberculosis from 1 mm. to 1 cm. in diameter. The bronchial glands on both sides are completely tuberculous, and a few small foci of tuberculosis are present in the mediastinal glands. One lymph gland at the curvature of the stomach contains a minute center of tuberculosis, and the mesenteric glands generally are sprinkled with small necrotic foci.

Hog No. 1846.—Killed April 7, 1906. General condition excellent; fat. Both submaxillary lymph glands are enlarged and tuberculous. Lung thickly sprinkled with minute foci of tuberculosis, and contains a few nodules between 1 and 2 cm. in diameter. Bronchial glands on both sides show tuberculous lesions. The liver contains a small number of minute tubercles. All the glands in the gastro-hepatic chain and about one-half in the mesenteric chain contain minute tuberculous foci.

Hog No. 1847.—Killed February 26, 1906. General condition excellent; fat. The submaxillary glands on both sides are greatly enlarged and entirely tuberculous. The prescapular glands on the right side show lesions of tuberculosis. The superficial inguinal glands on the right side are enlarged and edematous. The bronchial glands on the right side, the gastric glands, and practically all the mesenteric glands contain minute foci of tuberculosis. The mesenteric glands are enlarged and very edematous.

Hog No. 1848.—Killed April 7, 1906. General condition excellent; fat. Both submaxillary glands are greatly enlarged and tuberculous. The left prescapular and the left superficial inguinal glands contain each a necrotic focus, about 3 mm. in diameter. The lung contains innumerable minute tuberculous foci, evenly sprinkled through the anterior, medium, and azygos lobes; the principal lobes are comparatively free from lesions. Bronchial glands on both sides contain small areas of tuberculosis. The liver contains numerous tubercles from 1 to 2 mm. in diameter. Each gland in the gastro-hepatic and mesenteric chains of lymph glands contains 1 or 2 tuberculous foci from 5 mm. to 1 cm. in diameter.

Hog No. 1849.—Killed April 7, 1906. General condition excellent; fat. The submaxillary glands are from 4 to 5 cm. in diameter, and completely tuberculous. Lung is homogeneously sprinkled with minute tubercles. The right bronchial gland contains one tuberculous focus 4 mm. in diameter. The liver shows a few minute tuberculous areas. One mesenteric gland contains a focus of tuberculosis about 3 mm. in diameter.

Hog No. 1850.—Killed February 26, 1906. General condition excellent; fat. Both submaxillary glands are greatly enlarged and almost completely tuberculous. The prescapular and superficial inguinal glands on both sides are enlarged, edematous, and are sprinkled with minute necrotic areas. The lung is evenly sprinkled with innumerable tuberculous foci, 1 to 2 mm. in diameter. Bronchial glands on both sides show lesions of tuberculosis. Liver is uniformly sprinkled with foci of tuberculosis from 1 to 2 mm. in diameter. The gastric and mesenteric glands are generally enlarged, edematous, and sprinkled with minute centers of tuberculosis.

HOGS FED BEHIND CATTLE AFFECTED WITH NATURAL TUBERCULOSIS.

Hog No. 1837.—Killed March 1, 1906. General condition excellent; fat. No lesions of disease found on autopsy.

Hog No. 1838.—Killed April 13, 1906. General condition excellent; fat. No lesions of disease found on autopsy.

Hog No. 1839.—Killed March 1, 1906. General condition excellent; fat. The glands at the angles of the jaws (submaxillary glands) were at least five times as large as normal and intensely congested. No other lesions of disease found. Unfortunately, the submaxillary glands were soiled at the time of autopsy with a knife that had been previously used to section tuberculous material, and hence no further examination of them, by the microscope or by inoculation test, was made.

Hog No. 1840.—Killed April 13, 1906. General condition excellent; fat. No lesions of disease found on autopsy.

HOGS FED BEHIND HEALTHY CATTLE THAT WERE INGESTING TUBERCLE BACILLI.

Hog No. 1841.—Killed March 1, 1906. General condition excellent; fat. No lesions of disease found on autopsy.

Hog No. 1842.—Killed March 1, 1906. General condition excellent; fat. The left submaxillary gland is enormously enlarged and tuberculous throughout. The corresponding gland on the right side is enlarged and sprinkled with hemorrhagic markings. The prescapular gland on the right side is sprinkled with necrotic foci. The lungs are homogeneously studded with tuberculous areas from 1 to 3 mm. in diameter. Both the bronchial and mediastinal glands are sprinkled with minute tuberculous foci. Liver and spleen and the glands of the gastrohepatic chain are sprinkled with minute tubercles. The mesenteric glands are normal.

Hog No. 1843.—Killed April 13, 1906. General condition excellent, fat. Submaxillary glands on both sides contain a few small tuberculous areas. A few small tubercles from 1 to 2 mm. in diameter are found in the lung. No other lesions of disease.

Hog No. 1844.—Killed April 13, 1906. General condition excellent; fat. The right submaxillary gland is greatly enlarged and completely tuberculous. The lung is evenly sprinkled with innumerable tuberculous nodules from 1 to 2 mm. in diameter. The liver contains a much smaller number of similar nodules. No other lesions of disease.

HOGS INFECTED BY SUBCUTANEOUS INJECTION.

Hog No. 1751.—Killed March 23, 1906. At the seat of the inoculation is an abscess of about 5 mm. in diameter, which contains a dry, firm, cheesy material. The subcutaneous tissues surrounding the abscess, in a band less than 3 mm. wide, are sprinkled with minute necrotic foci. The lung contains a few small pearl-like tubercles, homogeneously distributed, 2 mm. and less in diameter.

Hog No. 1754.—Killed March 23, 1906. At the seat of inoculation is an abscess about 1 cm. in diameter, which contains a dry, firm, cheesy material. The subcutaneous tissues surrounding the abscess, in a band not more than 5 mm. wide, are sprinkled with minute necrotic foci. The lung is uniformly sprinkled with innumerable pearl-like tubercles, the largest of which are 2 mm. in diameter. The liver contains a few tuberculous foci 1 mm. and less in diameter. The spleen contains a very small number of tubercles from 1 to 2 mm. in diameter.

Hog No. 1755.—Killed March 23, 1906. Lesions at the seat of inoculation similar to that found in hog No. 1754. The inguinal lymph glands are slightly enlarged and contain several necrotic, tuberculous masses from 2 to 3 mm. in diameter. The prescapular lymph glands are slightly enlarged, and contain several necrotic, tuber-

culous areas, from 2 to 3 mm. in diameter; the number of affected areas is slightly greater than in the inguinal glands. The lung is evenly sprinkled with innumerable, minute, pearl-like tubercles, the largest of which are 2 mm. in diameter. The bronchial lymph glands are enlarged and contain a small number of tuberculous areas. The liver is homogeneously sprinkled with innumerable very minute tubercles. The portal lymph glands contain a small number of minute tuberculous foci. The spleen contains several tubercles from 1 to 3 mm. in diameter.

Hog No. 1772.—Killed March 23, 1906. At the seat of the inoculation is an abscess about 5 mm. in diameter, which contains a dry, firm, cheesy material. The subcutaneous tissues surrounding the abscess, in a band less than 3 mm. wide, are sprinkled with minute necrotic foci. The lung contains many pearl-like tubercles, 2 mm. and less in diameter, located mostly in the apexes of the principal lobes. The liver contains a few small tubercles, the largest of which are 2 mm. in diameter.

Hog No. 1783.—Killed March 23, 1906. At the seat of the inoculation is an abscess about 1 cm. in diameter, which contains a dry, firm, cheesy material. The subcutaneous tissues surrounding the abscess, in a band not more than 5 mm. wide, are sprinkled with minute necrotic foci. The lung is evenly sprinkled with innumerable minute, pearl-like tubercles, 2 mm. and less in diameter. The liver contains a considerable number of very minute tubercles. The portal lymph glands contain a few very minute tuberculous foci.

Hog No. 1790.—Killed March 23, 1906. At the seat of the inoculation is an abscess about 1 cm. in diameter, the wall of which is a heavy, dense, neoplastic tissue, which incloses a mass of dry, firm, cheesy material. The lung contains about a score of minute, pearl-like tubercles, the largest of which is not more than 2 mm. in diameter. The liver shows one small tubercle, not more than 1 mm. in diameter.

Hog No. 1798.—Killed March 23, 1906.—The lesion at the seat of the inoculation is similar to that found in hog No. 1754. Lung homogeneously sprinkled with numerous pearl-like tuberculous nodules, from 1 to 2 mm. in diameter. The liver contains a few minute tubercles.

Hog No. 1801.—Killed March 23, 1906. At the seat of the inoculation is a lesion similar to that found in hog No. 1772, only about twice as large. The lung is sprinkled with numerous tuberculous nodules, from 1 to 3 mm. in diameter. The liver contains a few very small tubercles.

Hog No. 1803.—Killed March 23, 1906. At the seat of the inoculation is a lesion similar to that found in hog No. 1783, but not more than one-half as large. The inguinal lymph glands are enlarged, and some of them contain a small number of necrotic areas 4 mm. and less in diameter. The lung is uniformly sprinkled with innumerable tuberculous nodules, from 1 to 4 mm. in diameter. The bronchial lymph glands are enlarged and thickly studded with minute necrotic foci. The liver is sprinkled with numerous tubercles, the largest of which are 3 mm. in diameter. The portal lymph glands are enlarged and sprinkled with many necrotic foci from 1 to 2 mm. in diameter. The spleen contains a few tuberculous areas from 1 to 5 mm. in diameter. The lymph glands at the curvature of the stomach are enlarged and sprinkled with necrotic foci from 1 to 2 mm. in diameter.

Hog No. 1805.—Killed March 23, 1906. At the seat of the inoculation is an abcess in all respects similar to that found in the same region in hog No. 1751. The lung is homogeneously sprinkled with innumerable pearl-like tubercles, which vary in size from mere points to 2 mm. in diameter. The liver contains a few tuberculous foci 2 mm. and less in diameter.

Hog No. 1809.—Killed March 23, 1906. At the seat of the inoculation is a lesion precisely similar to that found in hog No. 1801. The lung is evenly sprinkled with pearl-like tubercles from 1 to 2 mm. in diameter. The liver contains a few very minute tubercles.

Hog No. 1811.—Killed March 23, 1906. At the seat of the inoculation is a lesion similar in all respects to that found in hog No. 1783. One of the inguinal lymph glands contains a few minute tuberculous foci. The lung is uniformly sprinkled with numerous pearl-like tubercles 2 mm. and less in diameter. The bronchial lymph glands are greatly enlarged and sprinkled with tuberculous foci, some of which have a diameter of 2 mm. The liver contains many tubercles from 1 to 3 mm. in diameter. The portal lymph glands contain several minute foci of tuberculosis. The spleen contains several tuberculous foci from 1 to 3 mm. in diameter.

Hog No. 1895.—Killed April 7, 1906. General condition excellent. No lesions of disease found on autopsy.

SOME METHODS BY WHICH HOGS MAY CONTRACT TUBERCULOSIS.

PLAN OF THE EXPERIMENT.

As we have already stated, the hogs used in the tuberculin tests are divided into five groups. Of these, Groups I, II, and III form part of a separate experiment made to gain information on the manner in which hogs become affected with tuberculosis in their natural environment. The hogs of Group IV have already been discussed in a previous article,[a] and the hogs of Group V are healthy, and it is not necessary that anything should be added to what has been said about them. Groups I, II, and III will be dealt with separately in detail.

HOGS OF GROUP I.

Hogs Nos. 1853, 1854, 1855, 1856, 1857, and 1858 were each fed daily 1,000 c. c. of artificially infected milk on December 18, 19, and 20, 1905. Hogs Nos. 1845, 1846, 1847, 1848, 1849, and 1850 were each fed daily 1,000 c. c. of artificially infected milk for thirty days, beginning December 7, 1905.

The milk was infected in the following manner: The surface growth of an agar culture of tubercle bacillus was scraped off and thoroughly broken up in 10 c. c. of sterile water, and the resulting faintly clouded suspension added to normal milk from healthy cows at the rate of 1 drop of suspension to 50 c. c. of milk. A fresh suspension of tubercle bacillus was made every other day.

With the exception of No. 1858, all the hogs contracted tuberculosis. No. 1853 died February 21, 1906, affected with generalized tuberculosis.

HOGS OF GROUP II.

Hogs Nos. 1837, 1838, 1839, and 1840 were placed in a small inclosure about 5 by 10 meters (approximately 2 square rods) in area, into which the feces of two tuberculous cattle, confined in an adjacent stable, were thrown. The cattle were fed heavily with corn in the manner in common practice on western farms in fattening cattle, behind which hogs are turned. The tuberculous condition of the cattle was

[a] Bulletin No. 86, Bureau of Animal Industry.

known through the agency of a tuberculin test; they had no cough and were not visibly diseased. Their feces were eagerly eaten by the four hogs. The exposure began December 7, 1905, and lasted until February 26, 1906, a total of eighty-one days.

On postmortem examination three of the hogs were found to be free from all lesions of disease, and one hog, No. 1839, had greatly enlarged and intensely congested submaxillary lymph glands. The tuberculin test of this hog, which was made on the two days immediately before it was killed, gave a positive reaction, and this, together with the fact that the submaxillary glands of hogs are among the first to become infected and are almost invariably infected when tuberculous material has been ingested, makes it very probable that the enlarged and congested condition of the glands was due to incipient tuberculous disease. There is little doubt that the glands would have shown well-marked tuberculous lesions had the hog been permitted to live two or three weeks longer.

HOGS OF GROUP III.

Hogs Nos. 1841, 1842, 1843, and 1844 were placed in a small inclosure about 5 by 10 meters in area, into which the feces of two healthy cattle were thrown. The cattle were confined in a stable adjacent to the inclosure, and received water to drink which was infected with material from a beef-broth culture of tubercle bacillus. The growth in the liquid culture was thoroughly broken up and added to the drinking water of the cattle at the rate of 1 drop per 50 c. c. of water. The suspension of bacilli in the beef broth gave it a distinct turbidity. The cattle were securely fastened in the forward ends of comparatively narrow stalls, and the infected water was taken to them through a passage in front of the stalls and was placed in iron receptacles. Precautions were taken to prevent anything to the rear of the cattle from becoming infected with drippings from their noses and mouths after immersion in the water, and it is very improbable that any infectious material reached the rear of the cattle without first passing through their intestines. In all respects, excepting the infection of the drinking water, the cattle were treated precisely as the two tuberculous animals used in connection with the hogs of Group II. The exposure began December 7, 1905, and lasted until February 26, 1906, a period of eighty-one days.

On postmortem examination one of the hogs, No. 1841, was found to be free from lesions of disease and three were found to be affected with tuberculosis.

ANALYSIS AND DISCUSSION OF RESULTS.

The hogs of Group I show how readily these animals contract tuberculosis through the ingestion of milk infected with tuberculous material, and this fact is strongly emphasized by the results obtained

with 52 guinea pigs which were fed during three days with milk infected with tubercle bacilli in the same way as that given to the hogs. The guinea pigs were deprived of all food and drink for twenty-four hours before the milk was placed before them, and ingested about 175 c. c. each during the three days they were fed. They were killed about two months later and carefully examined postmortem, and not a lesion of tuberculosis was discovered.

If we take the total quantity of infected milk ingested by the 6 hogs that were fed three days, we have 18,000 c. c., and the total amount ingested by the 52 guinea pigs, we have 9,000 c. c. The average weight of the guinea pigs at the time they were killed was 624 grams (about 22 ounces) each, and of the hogs 34 kilograms (about 75 pounds) each; that is to say, the entire number of guinea pigs, representing 52 units that were exposed to infection, did not weigh quite as much as one of the hogs. Now, the remarkable fact is that 5 of the 6 hogs became affected with tuberculosis, and the entire 52 guinea pigs, which must certainly be regarded when the weight of the animals, the amount of milk ingested, and the number of units exposed are taken into consideration to have had a much more severe exposure, remained perfectly healthy. Two conclusions can be drawn from the experiment—either that hogs are very susceptible or that guinea pigs are very insusceptible to tuberculosis when the infectious agent is introduced into their bodies with food and the exposure is through the mouth, stomach, and intestines. Both conclusions are actually just and reasonable.

The insusceptibility of the guinea pigs is contrary to the usually accepted view of their high susceptibility, but the same condition was found with numerous other guinea pigs that were exposed to tuberculosis through ingestion and is perfectly compatible with the history of the thousands of guinea pigs that have been handled at the Bureau Experiment Station, where no spontaneous case of tuberculosis has ever been known to occur among guinea pigs.

That the tubercle bacillus used in these experiments was strongly virulent for guinea pigs was shown by a number of subcutaneous injections made with it, which caused rapidly fatal generalized tuberculosis in every guinea pig injected. Guinea pigs are extremely susceptible to tuberculosis when the infectious material is introduced under their skin or into their peritoneal cavity. In an article published in the Twenty-first Annual Report of the Bureau of Animal Industry for the year 1904, page 57, it was shown that the difference in delicacy between ingestion and intraperitoneal injection of milk as a test for the presence of tubercle bacilli is as 1 to 12,000, when guinea pigs are used as the test animal. While this proportion is, of course, based on an insufficient number of tests to permit its acceptance as absolutely correct, with the additional evidence furnished by the 6

hogs and 52 guinea pigs fed with artificially infected milk we are justified in concluding that little information can be gained about the infectiousness of milk from tuberculous cows by feeding it to guinea pigs, unless the guinea pigs contract tuberculosis, in which case we have evidence only that the milk tested in this way is very infectious.

The hogs of Group II did not give sufficiently definite results for quite satisfactory conclusions, although one of the four was almost certainly infected with tuberculosis, through no greater exposure than to feces of tuberculous cattle. It is reasonable to suppose that tubercle germs that are coughed up and swallowed by tuberculous cattle, or that reach their organs of digestion in some other way, may pass through the intestine and retain their original pathogenic virulence. The hogs of Group III show positively that tubercle germs swallowed by cattle may appear in their feces. Three out of the four hogs exposed to the feces of the two cattle that drank infected water contracted tuberculosis.

The system in practice in many portions of the country of turning a herd of hogs behind a herd of cattle that are being fattened for market may be accountable for tuberculosis among hogs if the disease exists among the cattle. Hogs associated in this way with cattle may be protected effectually from tuberculosis by applying the tuberculin test to the cattle and removing every animal from the herd that shows a reaction indicative of the presence of tuberculosis. And it is strongly recommended that, in regions where tuberculosis among hogs has been discovered, the cattle with which they are associated be first of all tested and reacting animals segregated or disposed of in a way that will insure against further harm from them.

The experiment of exposing hogs to the feces of tuberculous cattle and cattle that are swallowing infectious material is being repeated, and in the experiment now in progress even greater care is being taken than in the foregoing to prevent the introduction into the hog pens of any infectious material other than that which has actually passed through the bowels of the cattle.

By emphasizing the insusceptibility shown by our guinea pigs to tuberculosis through ingestion we do not wish to imply that it is safe for other species of animals and man to ingest material infected with the germs of tuberculosis; the contrary is shown to be true by the results obtained with the hogs, and by the greater frequency with which abdominal tuberculosis occurs among children during the age when milk forms a large portion of their diet, than among adults.

LOCATION OF LESIONS PRODUCED BY FEEDING EXPERIMENTS.

The distribution of the tuberculous lesions in the hogs that became affected with tuberculosis through the ingestion of the artificially infected milk and feces is shown in the following table. The table

shows simply in what glands and organs tuberculous lesions were found on postmortem examination, and no attempt is made to indicate the extent to which the involved organs and glands were affected.

Table showing distribution of lesions found in hogs exposed to tuberculosis through ingestion of infectious material.

Hog. No.	Lymph glands.										Organs.		
	Submaxillary.	Postpharyngeal.	Prepectoral.	Bronchial.	Mediastinal.	Hepatic (or portal).	Gastric.	Mesenteric.	Prescapular.	Superficial inguinal.	Lung.	Liver.	Spleen.
1853	+	+	+	+	+	+	+	+	.....	.....	+	+	+
1854	+	.....	.....	+	.....	+	+	+	+	.....	+	+	+
1855	+	.....	+	+	.....	+	+	+	.....	.....	+	+	+
1856	+	.....	.....	.....	.....	.....	.....	+	.....	.....	+	.....	.....
1857	+	.....	.....	.....	.....	.....	.....	+	.....	.....	.....	.....	.....
1845	+	.....	.....	+	+	.....	+	+	+	+	+	.....	.....
1846	+	.....	.....	+	.....	+	+	+	.....	.....	+	+	.....
1847	+	.....	.....	+	.....	.....	+	+	+	.....	.....	.....	.....
1848	+	.....	.....	+	.....	+	+	+	+	+	+	+	.....
1849	+	.....	.....	+	.....	.....	.....	+	.....	.....	+	+	.....
1850	+	.....	.....	+	.....	.....	+	+	+	+	+	+	.....
1839	+ ?	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1842	+	.....	.....	+	.....	+	+	.....	+	.....	+	+	+
1843	+	.....	.....	.....	.....	.....	.....	.....	.....	.....	+	.....	.....
1844	+	.....	.....	.....	.....	.....	.....	.....	.....	.....	+	+	.....
Total	15	1	2	10	2	6	9	11	6	3	12	9	4

The table shows that the submaxillary lymph glands, located at the angles of the jaw, were affected in every hog. These glands probably receive the drainage from the lips and a considerable portion of the mouth, and may be of such structure in hogs that it is difficult for tubercle germs to pass through them.

The lung, next in order, is the most frequent seat of disease. It was affected twelve times out of a possible fifteen, and in every instance contained the largest number of individual foci and the largest actual mass of tuberculous disease. The course taken by the infectious agent, with ingested tuberculosis, to the lung, is believed to be through the lymph channels and the blood. The former terminate in the vessels that carry the venous blood directly to the heart, and from the heart it is carried to the lung, where the germs are more or less effectually filtered out during its passage through the exceptionally fine and complex network of thin-walled capillaries. The innumerable lesions in the lung, and their more or less uniform distribution, both tend to support this view. This mode of infection is very strongly brought out in the experiments of Nicholas and Descos and of Ravenel, who proved by feeding healthy dogs on tuberculous fluid and examining the chyle in the thoracic duct a few hours later that tubercle bacilli may readily pass through the normal intestinal wall and infect the animal without causing any lesion in the alimentary tract.

The inhalation theory of the infection of the lung with tuberculosis is clearly shown to be unnecessary, and the frequency with which the

lung is affected among the experimental hogs, all of which contracted the affection through the ingestion of infectious material, shows that, although tuberculosis is more commonly a disease of the lung than of other organs, this is not necessarily due to the direct exposure of the lung to air in which tubercle bacilli are suspended. It is more probable that the infecting agent reaches the lung through the lymph and blood streams, as indicated, than through the air. When air in which solid particles are suspended is breathed, the tortuous, narrow passages, with moist surfaces, through which it must pass, should completely prevent the penetration of these solid particles to any great depth. The solid particles would lodge on the upper respiratory surfaces, and if not removed normally with mucus and other secretions through the mouth and nose, would be more apt to cause an affection of the local lymph glands, like the parotid, buccal, maxillary, pharyngeal, etc., than of the lung and the bronchial and mediastinal glands.

Next in the order of frequency with which various structures in the bodies of the hogs were affected are the mesenteric glands—eleven times in a possible fifteen. The mesentric disease was confined three times to a slight involvement of a single gland and one time to minute lesions in three or four glands. More general disease, with involvement of 33 per cent or more of the mesenteric glands, occurred seven times.

It should be noted that some relationship exists between the severity of the mesenteric disease and the severity of the exposure to which the hogs were subjected. Thus, 4 hogs that contracted tuberculosis through eating infected feces, the mildest form of exposure received, showed no disease of the mesenteric glands; 3 of the 5 hogs that were fed infected milk for three days showed very slight disease of the mesenteric glands, and 5 of the 6 that were fed infected milk for thirty days showed severe disease of the mesenteric glands.

In connection with the infection of the mesenteric glands it must be stated that the hogs used in the exposures to tuberculosis were young animals, less than 6 months old at the time they were killed and examined. Young animals and children have more voluminous lymph glands than older animals and adults, and their lymph glands are more frequently involved in disease. This may account to some extent for the frequency with which tuberculous lesions occurred in the mesenteric glands of the experimental hogs, as it does for the greater frequency with which abdominal tuberculosis occurs among children than among adults.

The bronchial glands stand fourth in the order of frequency, and were affected ten times in a possible fifteen, only one time less than the mesenteric glands. In every instance but one the affection of the bronchial glands was associated with disease of the lung, while the lung was affected three times without disease of the bronchial glands.

The order of frequency following the bronchial glands is, fifth, the

liver and the gastric glands (glands at the curvature of the stomach), each affected nine times; sixth, hepatic (portal) and prescapular glands, each affected six times; seventh, spleen, affected four times; eighth, superficial inguinal glands, affected three times; ninth, mediastinal and prepectoral glands, each affected two times; and, tenth and last, postpharyngeal glands, affected a single time.

The disease of the hepatic, or portal, glands was associated in every case with disease of the liver, and the liver was affected three times without accompanying disease of these glands. The disease in the liver generally partook more of the character of the lesions in the lung than in other structures—that is, with reference to the wide, even distribution of the foci of disease in the organ. The actual number of tuberculous foci in the liver was generally much smaller than in the lung.

The infrequency with which the mediastinal glands were affected as well as the comparatively great frequency with which remote glands like the prescapular and superficial inguinals contained lesions of tuberculosis is remarkable, and directs attention to the possibility of the infection of the meat of hogs even when their internal organs do not show lesions of extensive tuberculous disease.

The similarity in the distribution of the foci of disease in the lung and in the liver points directly to a similarity in the modes of infection, which, with both organs, is undoubtedly through the blood stream. Next to the lung no organ in the body has a capillary circulation that is as well adapted as that of the liver to act as a filter for the blood. If infectious material enters directly into the circulation through the capillaries supplied to the absorbing structures of the intestine, it is carried to the liver and has a chance to lodge there before it reaches the lung. The effectual manner in which the lung and the liver act as filters for the blood stream accounts for the infrequency with which tubercle bacilli can be detected in the blood of the general circulation.

SUMMARY OF PRACTICAL CONCLUSIONS.

1. The application of the tuberculin test to hogs is practicable, and the results obtained are as reliable as with cattle, provided the hogs are kept very quiet beginning some time before and throughout the entire test. The need for quiet can not be too much emphasized.

2. Hogs readily contract tuberculosis through the ingestion of infected food. Their susceptibility to tuberculosis through exposure to infected food is much greater than that of guinea pigs.

3. The feces of cattle that swallow tubercle bacilli are highly infectious for hogs that are exposed to them.

4. The feces of tuberculous cattle very probably contain numerous tubercle bacilli that reach the intestine through swallowing or otherwise.

5. Apart from the invariable infection of the submaxillary glands,

and the apparent dependence of the severity of the disease in the mesenteric glands on the amount of infectious material swallowed, the location of the tuberculous lesions in the body is undoubtedly dependent upon other causes than the channel through which the infectious material enters. This is especially shown to be true by such hogs as Nos. 1843 and 1844, in one of which the lesions were confined, in addition to the submaxillary glands, exclusively to the lung, and in the other to the lung and the liver.

While no hogs were included in the present experiments that were fed milk from tuberculous cows, we judge from experiments previously made, in which hogs were fed large quantities of such milk, that of the two methods—the exposure of hogs to the feces or to the milk of tuberculous cattle—the former has by far the greater danger, entirely apart from the fact that exposure to the feces, in the manner in which it occurs, is never a simple exposure to one thing, but a general exposure to all the infectious material that may pass from cattle irrespective of whether they are milk-producing animals or not.

Beef cattle behind which hogs are turned are usually young animals, and the percentage of tuberculosis among them, and more especially generalized or advanced tuberculosis, is very low. Dairy cattle, the average age of which is greater, show a much higher percentage of disease, and for this reason hogs associated with them will probably contract tuberculosis more frequently. This greater frequency must not be attributed entirely to the milk the hogs receive from the cows. No farmer and no dairyman who is acquainted with the value of the undigested grain or other nutriment in cattle feces as a food for hogs fails to feed as much of it as he possibly can. At the Experiment Station of the Bureau of Animal Industry several lots of hogs were kept, for experimental purposes, under identically the same conditions with the exception that some, in addition to their other feed, received a few shovelfuls of cow feces daily, and some a small quantity of milk. The results showed conclusively that either feces or milk caused an improvement in the condition of the hogs greatly in excess of what can be accounted for by the actual nutriment contained in the feces or milk. The feces when given with the ordinary feed produced results fully as good as the milk. Of three lots of hogs, all of which received the maximum amount of mill feed they could be made to eat, one lot was fed a small quantity of milk daily, and one the nutriment contained in a small quantity of cow feces. At the end of three months the hogs that received either milk or feces were in equally good condition, and had made a gain in weight of from 75 to 100 per cent greater than that made by the lot of hogs fed purely on mill feed.

It is a question whether the tuberculosis that occurs among hogs associated with dairy establishments is not more directly traceable to

the feces of tuberculous cows than to skim milk. Tuberculous cows with unaffected udders secrete milk infected with tubercle bacilli so rarely that the injection of such milk into the peritoneal cavities of guinea pigs (which is an exceedingly delicate test for the presence of tubercle bacilli) led to the inference in earlier investigations[a] "that if all cattle affected with advanced generalized tuberculosis and all cattle with diseased udders were eliminated from dairy herds, very little infected milk would reach the market." This inference should be modified by the conclusions drawn from investigations published in the Twenty-first Annual Report of the Bureau of Animal Industry (p. 65), in which it is pointed out that the danger that milk may become infected from the environment of tuberculous cattle is probably greater than through the milk-secreting structures of tuberculous cows with healthy udders, and hence that no tuberculous animals should be allowed to remain among dairy cattle or in dairy herds. This latter conclusion is still further emphasized by the results obtained in the experiments recorded in Bulletin No. 44 of this Bureau.

The feces of tuberculous cattle are a menace to hogs even when not deliberately fed to them. Very few establishments that keep both hogs and cattle make provisions effectually to prevent the access of the former to the manure heap on which the droppings of the latter are thrown. No farmer or stockman intentionally practices a system of feeding that is lacking in economy, and to know the benefits that are derived by hogs from the manure heap of stables containing heavily grain-fed dairy or beef cattle immediately causes its location in the hog yard. This practice is not harmful when the cattle are healthy; but when they are affected with tuberculosis it means, in the light of the evidence we now have, an almost certain transference of the disease to the hogs.

The following abstract of the work of H. Vallée, published in the Annales de l'Institut Pasteur, October 25, 1905, page 619, is very significant, and adds weight to the reasons we have presented relative to the frequency with which the lung becomes affected with tuberculosis and the channels through which the infectious material reaches the lung. Vallée draws attention to the incontestable fact that the pulmonary parenchyma constitutes the favorite seat for the location of the tubercle bacillus in all species of animals.

In statistics collected on 43,000 bovines the lungs have been shown to be affected in 75 per cent of cases of localized tuberculosis, and in all cases of generalized tuberculosis. Vallée inoculated 2 young calves by the intratracheal method and found on post-mortem examination six months later that the bronchial and mediastinal lymph glands and the lungs were without lesions, with the exception of 10 tubercular vegetations on the visceral pleura. Four other calves were infected by blowing a small

[a] Bulletins Nos. 3 and 7, Bureau of Animal Industry.

quantity of a pulverized culture of virulent tubercle bacilli into the naso-pharynx. In two of these cases the postpharyngeal lymph glands became involved, in one case the postpharyngeal and tracheal lymph glands developed lesions, while in the fourth calf the postpharyngeal, cervical, and tracheal glands showed tuberculosis, but in no instance were the pulmonary lymph glands, lungs, or other viscera affected.

Experiments were also carried out which seemed to indicate that an infection through the digestive tract constitutes a mode of inoculation which is extremely favorable to the production of pulmonary lesions.

As a result of his investigations Vallée concludes that of the various methods of infection ingestion is the one by which the most certain and the quickest tuberculization of the pulmonary lymph glands takes place. Moreover, the tubercle bacillus may pass through the intestinal walls without producing any appreciable lesion in the mucous membrane of the intestine or in the mesenteric lymph glands, and locate and multiply in the bronchial lymph glands.

The fact that it is difficult to produce tuberculosis of the lung and its lymph glands by direct injection of infectious material into the trachea is especially significant, while the conclusion that tubercle bacilli may pass through the intestinal walls and the neighboring lymph glands is in perfect harmony with the results obtained from our experiments.

Finally, we wish to add that the microscopic examination and inoculation tests of the feces and of scrapings from the walls of the rectum just inside of the anal opening of the cattle that drank infected water showed the presence of a considerable number of tubercle bacilli. The germs were all isolated and not in clumps. This fact shows more conclusively even than the tuberculous condition of the hogs exposed to the feces that the tubercle bacilli swallowed by the cattle actually passed through their stomachs and intestines and out through their rectums. The microscopic examination and inoculation test of the feces from an old tuberculous cow, not used in the experiment, that had been affected a number of years with naturally acquired tuberculosis, also showed the presence of tubercle bacilli, but in much smaller numbers than the feces of the cattle that drank the artificially infected water.

And this passage of tubercle bacilli, without loss of their pathogenic quality, from the mouth on entirely through and out of the intestinal tract of cattle, which is here experimentally demonstrated to be a fact, again leads us to call attention to the danger that normal milk from healthy cattle may be highly infectious if the dairy cows by which it is produced are stabled or pastured or otherwise associated with tuberculous cattle.

The desirability of the application of the tuberculin test to all cattle increases with every new investigation of the subject made.

O

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY.—BULLETIN No. 89.

A. D. MELVIN, CHIEF OF BUREAU.

INVESTIGATIONS IN THE MANUFACTURE AND STORAGE OF BUTTER.

II.—PREVENTING MOLDS IN BUTTER TUBS.

BY

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WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1906.

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(Concluded on p. 3 of cover.)

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY.—BULLETIN No. 90.
A. D. MELVIN, CHIEF OF BUREAU.

POULTRY INVESTIGATIONS
AT THE
MAINE AGRICULTURAL EXPERIMENT STATION.

BY

CHARLES D. WOODS, Sc. D.,
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AND

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., July 16, 1906.

Sir: I have the honor to transmit herewith a manuscript entitled "Poultry Investigations at the Maine Agricultural Experiment Station," by Profs. Charles D. Woods and Gilbert M. Gowell, of that station. This is a revision of Bulletin No. 100 of the Maine Station, and describes the methods used there in poultry breeding and management. This work is now being done in cooperation with this Bureau. As the results already accomplished are of great value to poultrymen and there is a general demand for information as to the methods employed, I recommend the publication of this paper as a bulletin of this Bureau.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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POULTRY INVESTIGATIONS AT THE MAINE AGRICULTURAL EXPERIMENT STATION.

INTRODUCTORY.

For many years poultry work has been carried on at the University of Maine. It was not, however, until 1897 that the Maine Experiment Station decided to begin a series of poultry investigations on a somewhat extended scale. Since 1904 this work has been carried on in cooperation with the Bureau of Animal Industry of the United States Department of Agriculture. The details of the results will be published, when completed, in a bulletin of this Bureau. Although the principal object of the present bulletin is to state the methods of poultry management practiced at the Maine Experiment Station, it may not be amiss, because of the great interest which has developed in the matter, to report here a brief summary of the results thus far obtained in the experiments in breeding for egg production.

In 1897 the Maine Station erected a poultry house 150 feet by 16 feet, a brooder house 60 feet by 14 feet, and a half dozen small movable brooder houses. The plant was constructed for the purpose of investigation, and many experiments, chiefly feeding, were under way in the winter of 1897–98. Early in the spring of 1898 this poultry plant was entirely destroyed by fire, but the larger part of the stock was saved. Of course the experiments thus interrupted did not give definite results, but the records of the pens and careful observation of the birds showed marked differences in the egg production, which led to a change in the plan and scope of the investigations. These birds were from stock that had been bred at the experiment station for many years.

BREEDING FOR INCREASED EGG PRODUCTION.

When the poultry plant was rebuilt in 1898 it was decided to give up for the present definite feeding experiments and to confine the work of the station for several years to the problem: Can egg production be increased by breeding and selection? This work, which was begun in 1898, has been continued without interruption.

In breeding poultry such wonderful changes have been made in form and feather that it seems to have been demonstrated that at least in these particulars the laws of inheritance and transmission are as true with poultry as with cattle, sheep, and horses. Many attempts have been made to improve egg production by breeding. This work has

been done mostly with flocks rather than with individual fowls, in much the same way as if an attempt were made to improve the milk production of a herd by basing the breeding upon the milk and butter production of the herd as a whole, without reference to the work of the individual animals. While numerous related problems have arisen in connection with the work and some side questions have been studied, nothing has been allowed to interfere with the original plan of breeding for increased egg production.

This work was begun with three different varieties—Barred Plymouth Rock, White Wyandotte, and Light Brahma. With the particular strains at the Maine Station, the Barred Plymouth Rock seemed the most promising, and, as the problems became complicated, the work was reduced to this one variety.

The plans followed in this breeding work are based upon everyday, practical common sense, and are the same as would be used in building up a high-producing strain of dairy animals. Individual records of performance are kept. The large producers are mated with sons of large producers in the hope of obtaining a race of improved layers. In the first year's work three birds laid over 200 eggs each, and this fact led to the adoption of that number of eggs as the minimum performance for a "registered" bird. Other than this there was no reason for selecting 200 as the number of eggs necessary to entitle a bird to registration. Any other number, as 190 or 210, might have been taken with equal propriety, just as horsemen might have selected some other time than 2.30 by which to determine a standard horse.

The purpose of this work should not be misunderstood. It was not attempted to breed stock that would average a yield of 200 eggs per year. This is a high record—much higher, probably, than large flocks will be made to average. If the average yield of the hens of the breed should be increased to the extent of a dozen eggs per bird the value of the work would be many times its cost.

In this investigation inbreeding is strictly guarded against, as it is doubtful if the inbred hen has sufficient constitution to enable her to withstand the demands of heavy egg yielding. During only one season have birds as closely related as first cousins been bred together. Line breeding is followed, the matings now being only with distantly related birds. These breeding investigations have been in progress for seven years. The first year was consumed in testing pullets to find foundation stock. The second year cockerels were raised from the large-laying hens for future breeding, and the third year the first lots of pullets were raised from the selected stock, so that there are only the last four years in which to note results, and these four years can only show the first changes that have taken place. The stock commenced with was well bred, as flocks generally go. The hens averaged about 120 good brown eggs a year, and had been doing so for several years.

PEDIGREE CHARTS.

In order to make clear the methods of breeding and registering employed, there are given two pedigree charts which illustrate the breeding of the two classes of birds which are designated as "registered" and "unregistered." These terms are not used with reference to purity of blood, for the strain used is one of the oldest of the families of Barred Plymouth Rocks, having been bred at the University of Maine for twenty-five years from the best "Barred Rock" stock which was procurable at the time of starting. Every one of the birds is purebred in the same sense that all registered cattle, horses, sheep, and swine are purebred.

Each of the hens is numbered with duplicate bands, and individual book accounts are kept, whether she produces much or little. The same is true of all males so far as purity of blood is concerned.

In this work the term "registered" is used solely with reference to performance, which in work with Jersey or Holstein cattle would mean registered in the "advanced registers" of those breeds. No female has been registered unless she had laid 200 or more large dark-brown eggs during the first twelve months from the day on which she laid her first egg. None of her daughters have been registered unless they themselves had laid at least 200 eggs in their first laying year.

All of the sons of registered hens are registered and are designated as registered males. They are no better bred than their own sisters which are rejected from registry when they do not prove to be heavy performers. Were there some practicable means to determine the ability of the male to transmit to his offspring the high egg-producing function of his dam, the same rigid rule of selection would be applied to him that is applied to his sisters.

The unregistered cockerels and pullets are as well bred on their sires' side as the registered ones are, but, while the registered ones have dams that produced 200 eggs or over, the dams of the unregistered ones laid from 160 to 199 eggs in their first laying year. It is among these unregistered pullets that the most of the 200-egg producers that are each year added to the foundation breeding stock have been found.

The diagrams shown are given only as examples of the breeding. In the male breeding pens nearly 30 different hens are employed, which give as many different pedigrees. In the unregistered female breeding pens are several hundred breeding hens, each giving pedigrees to their progeny. In the diagram illustrating the breeding of the registered males it is shown that the dams and their dams were both producers of over 200 eggs. Only two other similar instances where the daughters of 200-egg producers are themselves 200-egg producers have been found. That more instances of this kind have not occurred is due to the fact that the hen that laid heavily her first year did not commence laying until so late the following year that her pullets came into laying too late in the year to make great records for themselves in the twelve months from November 1.

The first diagram shows the breeding of the registered males that were raised in the breeding year of 1905. The registered males are designated by numbers. It will be noted that the dam and the grandam of the registered males are registered birds in the sense in which we use the word, the dam having yielded 203 and the grandam 213 eggs in their first laying years. Beyond that, while the birds are purebred, their breeding is not known except that their dams laid not less than 160 and not more than 199 eggs in their first laying years. The breeding of the unregistered males and females raised in 1905 differs from the registered in that none of the mothers of the unregistered birds have laid over 199 eggs in their first laying year.

Diagram illustrating breeding of registered males raised in 1905.[a]

Registered males raised in 1905.
- No. 304....
  - No. 165....
    - No. 66 ....
      - No. 41 ....
        - No. 44 .... — No. 286 (206) / ....
        - No. 303 (208).... — .... / ....
      - No. 676 (209)....
        - No. 29 .... — No. 286 (206) / ....
        - No. - (150 to 199) — .... / ....
    - No. 1003 (240)...
      - No. 52 ....
        - No. 18 .... — No. 101 (204) / ....
        - No. 326 (211).... — .... / ....
      - No.—(150–(199)
        - No. 21 .... — No. 286 (206) / ....
        - No. — (150–199) — .... / ....
  - No. 205 A. (225)
    - No. 61 ....
      - No. 40 ....
        - No. 17 .... — No. 101 (204) / ....
        - No. 318 (237).... — .... / ....
      - No. 635 (201)....
        - No. 24 .... — No. 101 (204) / ....
        - No. — (150–199) — .... / ....
    - No. — (150–199)
      - No. 36, 37, 38, or 39.
        - No. 17 .... — No. 101 (204) / ....
        - No. 318 (237).... — .... / ....
      - No. — (150 to 199).
        - No. 24 .... — No. 286 (206) / ....
        - No. — (150–199) — .... / ....
- No. 520 (203)
  - No. 166....
    - No. 51 ....
      - No. 40 ....
        - No. 17 .... — No. 101 (204) / ....
        - No. 318 (237).... — .... / ....
      - No. 635 (201)....
        - No. 24 .... — No. 101 (204) / ....
        - No. — (150–199) — .... / ....
    - No. 1003 (240)...
      - No. 52, 53, 54, or 55.
        - No. 18 .... — No. 101 (204) / ....
        - No. 326–211 ..... — .... / ....
      - No. — (150–199)
        - No. 21 .... — No. 286 (206) / ....
        - No. — (150–199) — .... / ....
  - No. 1001 (213)
    - No. 62 ....
      - No. 41 ....
        - No. 44 .... — No. 286 (206) / ....
        - No. 303 (208).... — .... / ....
      - No. 676 (209)....
        - No. 29 .... — No. 286 (206) / ....
        - No. — (150–199) — .... / ....
    - No. — (150–199)
      - No. 45, 46, 47, or 48.
        - No. 24 .... — No. 101 (204) / ....
        - 318 (237)....... — .... / ....
      - No. — (150–199)
        - No. 13 .... — No. 286 (206) / ....
        - No. — (150–199) — .... / ....

[a] The upper number of each pair refers to the male (sire) and the lower number to the female (dam). The figures in parentheses below or at the right of the number of the hen indicate the egg yield for the first laying year.

Diagram illustrating breeding of unregistered males and females raised in 1905.[a]

- Unregistered males and females raised in 1905.
  - No. 302
    - No. 160
      - No. 66
        - No. 41
          - No. 44
            - No. 286 (206)
            - ....
          - No. 303 (208)
            - ....
            - ....
        - No. 676 (209)
          - No. 29
            - No. 286 (206)
            - ....
          - No. — (150-199)
            - ....
            - ....
      - No. 1003 (240)
        - No. 52
          - No. 18
            - No. 101 (204)
            - ....
          - No. 326 (211)
            - ....
            - ....
        - No. — (150-199)
          - No. 21
            - No. 286 (206)
            - ....
          - No. — (150-199)
            - ....
            - ....
    - No. 224 (222)
      - No. 61
        - No. 40
          - No. 17
            - No. 101 (204)
            - ....
          - No. 318 (237)
            - ....
            - ....
        - No. 635 (201)
          - No. 24
            - No. 101 (204)
            - ....
          - No. — (150-199)
            - ....
            - ....
      - No. — (150-199)
        - Nos. 36, 37, 38, or 39.
          - No. 17
            - No. 101 (204)
            - ....
          - No. 318 (237)
            - ....
            - ....
        - No. — (150-199)
          - No. 24
            - No. 286 (206)
            - ....
          - No. — (150-199)
            - ....
            - ....
  - No. — (150-199)
    - No. 159
      - No. 51
        - No. 40
          - No. 17
            - No. 101 (204)
            - ....
          - No. 318 (237)
            - ....
            - ....
        - No. 635 (201)
          - No. 24
            - No. 101 (204)
            - ....
          - No. — (150-199)
            - ....
            - ....
      - No. 1003 (240)
        - Nos. 52, 53, 54, or 55.
          - No. 18
            - No. 201 (204)
            - ....
          - No. 326 (211)
            - ....
            - ....
        - No. — (150-199)
          - No. 21
            - No. 286 (206)
            - ....
          - No. — (150-199)
            - ....
            - ....
    - No. — (150-199)
      - No. 62
        - No. 41
          - No. 44
            - No. 286 (206)
            - ....
          - No. 303 (208)
            - ....
            - ....
        - No. 676 (209)
          - No. 29
            - No. 286 (206)
            - ....
          - No. — (150-199)
            - ....
            - ....
      - No. — (150-199)
        - Nos. 45, 46, 47, or 48.
          - No. 24
            - No. 101 (204)
            - ....
          - No. 318 (237)
            - ....
            - ....
        - No. — (150-199)
          - No. 13
            - No. 286 (206)
            - ....
          - No. — (150-199)
            - ....
            - ....

[a] The upper number of each pair refers to the male (sire) and the lower number to the female (dam). The figures in parentheses below or at the right of the numbers of the hens indicate the egg yield for the first laying year.

SELECTION OF BREEDING STOCK.

METHOD USED AT THE MAINE STATION.

..n order to select good producing hens for foundation breeding stock, 52 of the trap nests described on page 36 were placed in the laying pens, where 140 pullets hatched in April and May commenced using them November 1, 1898. In one year from that date the 140 birds laid an average of 120 eggs each. Twenty-four laid over 160 each and 22 less than 100 each. Hen No. 36 laid 201 eggs; No. 101

laid 204, and No. 286 laid 206 eggs. The eggs of No. 36 were light in color,[a] and she was therefore rejected as a breeder.

At the commencement of the next breeding season Nos. 101 and 286 were mated with males that were unrelated to them or to each other. The cockerels raised from the eggs of these two birds were the first males produced for use in this work.

November 1, 1899, 160 pullets were placed in the testing pens. In the year beginning with that date they laid an average of 132 eggs each. Three laid over 200 eggs, and 19 laid over 160 eggs.

In the early spring of 1901 several sons of hen No. 286, raised the previous year, were mated with the 24 2-year-old hens that each laid 160 eggs and over during 1898–99, and 25 others that each laid 160 eggs or over during the 1899–1900 test. That season (1901) hen No. 303, which had laid 208 eggs during 1899–1900, was bred to a son of No. 286. Hen No. 326 had laid 211 eggs during 1899–1900, and she also was bred to a son of No. 286. No. 318 had laid 237 good brown eggs in 1899–1900; and after she had laid 200 eggs, the next dozen she laid weighed 1 pound 11¼ ounces. She was bred to a son of No. 101 that season. The sons of Nos. 101 and 286 were in service only during the spring of 1901.

During 1900–1901 100 pullets were tested for additional foundation stock and yielded an average of 132 eggs each. Twelve birds laid over 200 eggs each, the highest number being 251 eggs, laid by hen No. 617. In the same pens were six others that laid only from 23 to 70 eggs each. Thirty-seven laid over 160 each. No hens were used as breeders that had not laid at least 160 eggs, and all, as in the previous year, were bred to males whose dams had yielded over 200 eggs.

Males were raised in 1902, for the male breeding pens of the next year, from hens No. 635 (record, 201 eggs) and No. 676 (record, 209 eggs). The eggs from both of these hens were very large and dark brown. These hens were mated to sons of No. 303 and No. 318, before mentioned. Males for the pullet breeding pens of the next year were bred from other matings of hens that had produced 200 eggs with males whose dams had yielded over 200 eggs.

In the year 1901–2 the registered stock had increased to such an extent that there was only room to house 53 pullets for testing. They were the first pullets tested that were sired by males bred from 200-egg-producing hens, and show the first results of the breeding practiced. They had been laying quite heavily out on their summer range during September and October, although they were not hatched until April and May. The 53 birds laid 7,952 eggs in the year beginning November 1, 1901—a little better than 150 eggs each. Seven of the

[a] Only hens laying large dark brown eggs have been used in these breeding experiments.

53 showed records of from 201 to 240 eggs in the year, and 23 of the 53 laid over 160 eggs each.

During the breeding season of 1903 hens No. 1001 (record, 213 eggs), No. 1003 (240 eggs), No. 1005 (222 eggs), and No. 1140 (211 eggs) were bred to male birds raised the year before whose dams had yielded over 220 eggs each, for the purpose of procuring males for the breeding pens of 1904.

All pullets raised that year (1902) were, as in the preceding three years, the progeny of hens that had laid over 160 eggs in a year, and they had this advantage over their predecessors—that their dams and maternal grandams were sired by males whose dams had yielded 200 eggs or over.

That year (1902–3) 160 pullets were tested in the trap nests. They laid 21,202 eggs, an average of 132 each. Forty-four laid over 160 eggs each, 8 laid 200 or over, viz, 200, 205, 210, 217, 220, 221, 222, and 225 eggs each. An explanation for the lower average yield than that of the last preceding year is readily found. The pullets were hatched in April and May, and, thinking to have them in readiness for laying early in November, they were fed more beef scrap than usual during the growing season while they were out on the range. This so hastened their development that they began laying in August, and they were nearly all laying heavily during September, October, and November. They were splendid birds, but almost every one of them completely molted in December, and very few eggs were had from them for more than two months; most of the eggs secured from them were laid after the middle of January. Had they commenced laying in October and continued for a year, molting would probably have been avoided and the showing would have been much better.

The breeding season of 1904 opened with 170 4-year-old hens that had laid above 160 eggs each the year before, 80 pullets and hens whose dams had laid over 200 eggs per year, and 28 hens that had themselves laid over 200 eggs per year. These birds were in 24 different pens, and they were bred to selected cockerels whose dams had yielded above 200 large brown eggs per year.

Among the pullets tested during the preceding year (1903) were found the following: No. 263a yielded 220 eggs; No. 225a, 220 eggs; No. 222a, 221 eggs; No. 224a, 222 eggs, and No. 205a, 225 eggs. These birds were bred during 1904 to cockerels raised in 1903 from heavy-producing dams whose other sons were never used in these breeding experiments. The mating of these 5 pairs of birds was to secure cockerels for the next year's breeding.

At the usual time (November 1, 1903) for the commencement of the yearly test of 1903–4, 300 good pullets were laying well out on the range. The construction of the building to be used for their quarters

was interfered with by a question of labor, and they remained out in their small summer homes during a wet, cold fall and early winter until December 6, 1903, when they were moved in. This delay and exposure of more than a month cut into the year's work heavily, and the average production of the 300 birds was reduced to 131 eggs each during a little less than eleven months. Eight birds yielded above 200 eggs each before the close of October, 1904.

The breeding females used in the season of 1905 were tested hens that laid from 160 to 251 eggs in a year; and 150 pullets and hens whose dams produced 200 eggs or over per year. All males used in breeding since 1901 had dams that had laid 200 eggs or more in a year.

In 1904–5, 400 pullets from hens that had laid above 160 eggs a year, and whose sires, grandsires, and great grandsires were descended from hens that yielded above 200 eggs per year, were tested by the trap nests for additional breeding stock. All of the dams of these pullets had sires and grandsires that had 200-egg-producing dams. The average egg yield of these birds for the twelve months beginning November 1, 1904, was 147. Among them were 54 hens that laid over 200 eggs and 217 hens that laid over 160 eggs. The highest yield by any bird in 1904–5 was 239 eggs.

The stock with which this investigation began was well bred, as flocks generally go. The hens were averaging about 120 good brown eggs a year, and had been doing so for several years. In the year 1901–2, 50 selected birds averaged 150 eggs. In the two years 1902–3 and 1903–4, with the great setbacks caused as above indicated, which was no fault of the stock, the average was 132 eggs. The average from the 400 pullets in the testing pens in 1904–5 was 147 eggs. These were not selected birds, but were a fair average of all pullets raised that year. The stock was strong and vigorous and but few chickens that hatched were lost. The hardihood and vigor of the stock is shown by the fact that many cockerels have been sold to farmers and poultrymen during the past few years and many have ordered again, with the frequent comment that their pullets are laying earlier in the season and giving better eggs than they have ever done before.

As the housing, treatment, and food have been as nearly alike as possible, there seems to be reason for assuming that the increased flock yields are the results of the breeding practiced.

It may be contended that sufficient time has not yet elapsed since the beginning of these breeding tests to warrant the claim that increased productiveness has been established, but the outlook is certainly very encouraging.

OTHER METHODS OF SELECTING BREEDING STOCK.

There are two or three much-advertised methods of judging a hen's productiveness from certain signs and marks, the secret of which will

be disclosed by the inventor for a consideration. The Maine Station has not invested in nor investigated any of these methods. There may be ways to prophesy accurately what a hen will do in the way of egg production, but they have not come to the writer's attention.

EARLY LAYING A VALUABLE INDICATION.

The only absolutely sure way of making selection for breeding stock is by aid of the data obtained by the use of trap nests. Only investigators and an occasional poultryman, however, can afford the equipment and the expense involved in operating trap nests, but every poultryman can, by closely observing his young stock during the autumn, select the pullets that are commencing or preparing to lay, and secure for the next season's breeding a pen of birds that have the function of egg production so strongly developed that they give evidence of it by its early exercise.

As evidence of the value of early-laying pullets for breeders, attention is called to the work performed by 29 April-hatched pullets that were selected from among their sisters out on the range in August and September, when they showed that they were laying or about to begin laying. They were not selected because of form or type as indicating egg production, but they were either just picked up as they were found on the nests or taken because their combs were red or because they tagged the attendant around and prated in the everyday hen language about the work they were soon going to do. They were carried to the laying house, marked with bands, and given access to trap nests.

Four of these hens died within the year. The smallest layer of the remaining 25 laid 137 eggs the first laying year; 18 laid more than 160 eggs; and 8 laid over 200 eggs, and the average of the flock for the twelve months ending August 30, 1905, was 180 eggs. This average was much higher than that of all the pullets carried that year, and the flock contained no poor layers, but a phenomenal number of high layers. The high average of the flock and the large proportion of good layers point out the advantages of this method of selection when the use of trap nests, or other equally reliable methods of selection, is not practicable.

Early maturity in pullets is generally accompanied by physical vigor, and, when the function of such birds is to produce eggs and they give evidence of it, they are certainly the best of their race to breed winter egg producers from, if we accept past experiences as a guide.

The records of a full year's laying in trap nests would be better, as that would enable the rejection of all poor workers. As the birds would not be used for breeding purposes until the year following, they would be more mature, and the chicks would be larger when hatched and would develop into larger birds at maturity than they

would if their dams were doing their first year's laying. The differences in size from these causes have been very noticeable in our work.

Poultrymen are generally desirous of securing as many well-bred pullets as possible, and so use 1-year-old hens as breeders in addition to their 2-year-olds. The work done by pullets from September to February or March is a pretty good indication of their usefulness, and their eggs are available for breeding during the pullet year. While the chickens from such eggs are not generally so large at maturity as those from older hens, they do not appear to lack constitution or vigor, and there is no apparent reason why they are not desirable for breeding purposes.

POULTRY MANAGEMENT.

Many years' practical experience in raising and keeping poultry and investigations in poultry breeding at the Maine Experiment Station have resulted in the accumulation of a considerable fund of information on poultry management. It is the purpose of the following pages to outline this experience for the benefit of poultry keepers and thereby to help them to discriminate between some of the wrong theories which have underlain much of the common practice of the past and the better theories which underlie other and newer methods that are now yielding more satisfactory results. It may be that these methods are no better than those practiced by others, but the attempt is made to state concisely the methods which have been or are now being successfully employed at the station.

RAISING CHICKENS BY NATURAL PROCESSES.

While even the small grower of chickens is earnestly urged to use an incubator for hatching, circumstances sometimes make it necessary to hatch and raise chickens by aid of the mother hen. To persons so situated an outline of the method practiced at the station before incubators had reached their present development may be helpful. An unused tie-up in a barn was taken for the incubating room and a platform was made along the inner side. The platform was 3 feet above the floor and was 2½ feet wide and 50 feet long. It was divided into fifty little stalls or nests, each 1 foot wide, 2 feet long, and 1 foot high. This left a 6-inch walk along the front of the nests for the hens to light on when flying up from the floor. Each nest had a door made of laths at the front, so as to give ventilation. The door was hinged at the bottom and turned outward. Across the center of each nest a low partition was placed, so that the nesting material would be kept in the back end—the nest proper. For early spring work paper was put in the bottom of the nest, then an inch or two of dry earth, and on that the nest, made of soft hay.

Whenever half a dozen hens became broody they were taken in from the henhouse and put on the nests, each nest having a dummy egg in it; the covers were then shut up, and nearly every hen seemed contented. In a day or two 13 eggs were placed under each hen. Every morning the hens were liberated as soon as it was light, when they would come down of their own accord and burrow in the dry dust on the floor, eat, drink, and exercise, and in twelve or fifteen minutes they would nearly all go onto the nests voluntarily. In the afternoons one would occasionally be found off the eggs looking out through the slatted door. If she persisted in coming off she was exchanged for a better sitter. The double nest is necessary, otherwise the discontented hen would have no room to stand up, except on her nest full of eggs, and she would very likely ruin them. There was no danger of this with the double nest, as she would step off the nest, go to the door and try to get out.

The advantages of a closed room in which to confine the sitters are many, as the hens are easily controlled and do not need watching as they do when selecting nests for themselves, or when sitting in the same room with laying hens. A room 12 feet square could be arranged so as easily to accommodate 50 sitters.

The most satisfactory arrangement used at the Maine Station for the accommodation of the hen with her brood of young chicks consisted of a closed coop about 30 inches square, with a hinged roof and a movable floor in two parts, which would be lifted out each day for cleaning. This little coop had a wire-covered yard attached to it on the south side. The yard was 4 by 5 feet in size and 1½ feet high. Its frame was of 1-inch by 3-inch strips and was fastened securely to the coop.

The wire on the sides was of 1-inch mesh, but on top 2-inch mesh was sufficient. Such a coop is easily kept clean, and the coop and yard can be set over onto clean grass by one person.

The small run will be sufficient for the first few weeks, but soon the chicks need greater range, and then the fence at the farther end of the run can be lifted up 3 or 4 inches and they can pass in and out at will, while the mother will be secure at home and they will know where to find her when they get cold or damp or need brooding. Such a coop accommodates 15 to 20 chicks until they no longer require brooding, after which several flocks should be combined in one and put in a portable house on a grassy range.

Whenever the hen is allowed to hatch or to mother chicks, much care must be exercised to prevent lice from getting a foothold and ruining the birds. The free and frequent use of fresh insect powder upon the hen, working it through the feathers to the skin, is one of the best methods for destroying the pests. Grease or oil are effective when applied to the heads and under the wings of young chicks, but

care must be taken not to get too much on them, especially during damp weather. The feeding of chicks raised in coops with their mothers does not vary much from the feeding of those raised in brooders as described on page 20.

RAISING CHICKENS BY ARTIFICIAL PROCESSES.

Incubators have been so much improved that there are several kinds on the market that will hatch as many chicks from a given lot of eggs as can be done by selected broody hens. They require little care, maintain an even temperature, and are easily adjusted to meet the increase in temperature arising from the developments going on in the eggs. In some machines the moisture supply is automatic and adapted to the requirements; in others it has to be supplied, and skill is necessary in determining the quantity needed. The economy of the incubator is very great. A 360-egg machine will do the work of nearly 30 broody hens, and can be kept at work continually if desired.

THE INCUBATOR.

There are many makes of incubators on the market, most of which will give fairly satisfactory results. The Maine Station has not tested many makes of incubators and very likely some of the makes not tested would prove as satisfactory as the make used. Where many machines are used the hand turning of the eggs absorbs considerable time. Several turning devices have been used and equally good hatches have been obtained with them as when the eggs have been turned by hand. Machines that have artificial turning shelves will not hold quite as many eggs as when flat shelves are used, but the saving of time compensates for this.

Whatever make of incubator is used, pains should be taken to become thoroughly acquainted with the machine before the eggs are put into it. It would be desirable for a person not familiar with the use of an incubator to run the machine empty for several days before filling it. After the eggs are put in changes and adjustments should be made with the greatest care for fear of extreme results. By the use of an incubator it is possible to determine exactly the time when the chickens shall be hatched. With the strain of Barred Plymouth Rocks bred by the Maine Station it was formerly necessary to hatch the chickens in March in order to have them ready for November laying. By breeding from the best layers and hence the earliest developed birds, and by better methods of feeding and treatment, it is now possible to delay the hatching until April and the first of May and have the pullets in good laying condition the last of October and early in November. Chickens hatched in March under the present method of breeding and feeding would begin laying in August.

THE INCUBATOR ROOM.

It is important that the incubator room be so situated that it can be kept at a fairly constant temperature. On this account an underground room is usually selected. For many years the well-lighted cellar under the wing of the farmhouse was used by the Maine Station. A cold or damp cellar would, however, be poorly adapted for incubators. Ventilation is important, and where several incubators are in use artificial ventilation must be provided, in order that the machines may be furnished with clean, fresh air at all times.

In 1905 the Maine Station erected an incubator house (pl. 1, fig. 1) which practically consists of a well-made, light, airy cellar with a house for the poultryman above it. The incubator room, which occupies the entire cellar, is 30 feet square. The room is 7 feet high in the clear, 5 feet of which is below the level of the outside ground. It is lighted by six 3-light windows carrying glass 10 inches by 16 inches. The cement walls are finished smooth and the cement floor is slightly inclined toward the southeast corner where the intake of the drain is located. This enables the free use of water from hose in cleaning the room preparatory to starting the incubators. Two chimneys extend to the basement floor and contain ventilating flues that have no opening into the rooms above. Entrance to the room is through a covered outside cellar stairway leading into a shed at the rear of the building. The room now contains eighteen 360-egg machines, and by a little crowding would hold 21.

BROODER HOUSES.

The poultry plant erected by the Maine Station in 1897 included a permanent brooder house. The house was 14 feet wide by 60 feet long. Its front wall was 4 feet 10 inches high from the bottom of the sill to the top of the plate, and the back was 7 feet high. The ridge was 4 feet from the back side and 1 foot 6 inches higher than the back plate. This gave the short part of the roof back of the ridge and the long part to the front of it. The frame of the building was of 2 by 4's; it was boarded on the outside with hemlock boards, covered with paper, and shingled all over, and the building was ceiled on the inside with matched pine. This gave a 4-inch dead-air space in the walls and roof. The house also had a tight double floor with paper between. The front wall was 3 feet 8 inches high inside and the back wall 5 feet 9 inches from floor to ceiling. There was a 3½-foot door in each end; there were ten windows in the front wall, equal distances apart and 8 inches from the floor, and five windows in the back wall close up to the plate. The windows had 6 panes each of 10 by 12 inch glass, and the sash were in two parts so as to slide up and down and admit fresh air and to keep the house cool in warm weather. The windows were

all double. There were ten small doors, each 10 by 12 inches, placed close to the floor along the front wall, through which chickens could pass in and out; these doors were also double. Two galvanized iron ventilators at the top extended from the inside of the room up through the ridge and furnished sufficient ventilation during cold weather. The ventilators were regulated by means of a shut off at the ceiling.

The house was divided into ten breeding pens, each 6 feet by 10 feet 8 inches. The partitions between the pens consisted of an 8-inch board at the bottom with 3 feet of 1-inch-mesh wire above. A walk 2½ feet wide extended along the back of the building. The doors which led from the walk to the pens were made to swing both ways and were covered with wire. A brooder was placed in each pen with a lamp door opening into the walk. Each of these pens accommodated about 60 chicks in winter, or 75 in spring when they could get out into the yards. The building, being low posted, was kept warm enough in winter by the ten brooder stoves, and the temperature under the hovers was usually found in the morning about the same as it was left the night before.

This house proved to be thoroughly satisfactory, but was burned in the spring of 1897 and has not been replaced. A permanent brooder house would be indispensable for the raising of winter chickens, and a house piped for hot water would have some advantages over the one here described. The advantages are especially great when raising chickens if April or May prove to be cold or wet, for then the small houses are apt to be cold outside of the brooders. In ordinary seasons, even in Maine, little or no difficulty is experienced in raising chicks hatched in April and May in the small houses. The expenditure would be greater for the piped house, for the reason that colony houses should be provided in which the chickens may be sheltered after they leave the brooder house.

Since the burning of the house just described, the Maine Station has used small portable brooder houses (pl. 2). The small brooder houses built on runners are readily moved about, and for the work with spring-hatched chickens are preferred to the large permanent brooder house. Several styles and sizes have been used, but the following meets the needs of the station better than any other that has been tried. The houses are built on two 16-foot pieces of 4 by 6 inch timber, which serve as runners. The ends of the timbers, which project beyond the house, are chamfered on the underside to facilitate moving. The houses are 12 feet long; some of them are 6 feet and others 7 feet wide; 7 feet is the better width. They are 6 feet high in front and 4 feet high at the back. The frame is of 2 by 3 inch lumber; the floor is double boarded, and the building is boarded, papered, and shingled all over. In some localities roofing paper of good quality would be preferable to shingles for the outside covering

FIG. 1.--INCUBATOR HOUSE.

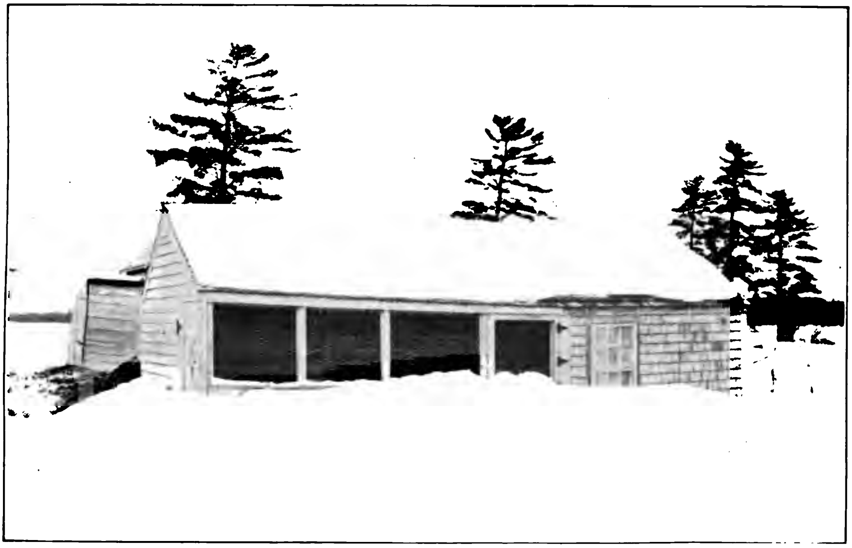


FIG. 2.—PIONEER ROOSTING-CLOSET HOUSE.

BROODER HOUSES ON THE RANGE.

of these houses. A half dozen built by the Maine Station in 1905 were covered with such roofing and are very satisfactory. This kind of covering for the wall is not so likely to be injured in moving as shingles. A door 2 feet wide is in the center of the front and a 6-light window, hinged at the top, is on each side of it. Two brooders are placed in each of these houses and 50 to 60 chicks are put with each brooder. A low partition separates the flocks while they are young, but later it has to be made higher. The houses are large enough so that a person can go in and do the work comfortably, and each one accommodates 100 chicks until the cockerels are large enough to be removed.

Indoor brooders are used at the Maine Station and are much preferred to any outside brooders the station has tried. The style used has the cover and part of one side arranged to turn down, making an inclining run the whole width of the brooder, up and down which the little chicks can go without crowding.

Most kinds of brooders as now made keep the chicks comfortable at desired temperatures and have good means of ventilation. The great difficulty lies in the lamps used. The lamp apartments are small and the tendency is for the oil to become warm and form gases which cause the flame to stream up and make trouble. Most brooder lamps have water pans between the oil tank and the burner which tend to keep the oil cool, but even with this precaution the Maine Station has had two fires, one of which was very serious. The brooders now in use have no water pans but are so arranged that currents of cool air pass constantly over the oil tank and keep its contents cool. These lamps, or stoves, have been used for four years—last year more than 20 of them—and they are apparently safe, as the oil in them has never become warm.

TREATMENT OF YOUNG CHICKS.

When the chicks are 30 to 40 hours old they are carried in warm covered baskets to the brooders, and 50 or 60 are put under each hover, where the temperature is between 95° and 100° F. The temperature is not allowed to fall below 95° F. during the first week, or 90° F. during the second week; then it is gradually reduced according to the temperature outside, care being taken not to drive the chicks out by too much heat, or cause them to crowd together under the hover because they are cold. They should flatten out separately when young, and a little later lie with their heads just at the edge of the fringe of the hover. They should never be allowed to huddle outside of the brooder. They huddle because they are cold, and they should be put under the hover to get warm, until they learn to go there of their own accord. Neither should they be allowed to stay under the hover too much, but in the daytime should be forced out into the cooler air

where they gain strength. They ought not to be allowed to get more than a foot from the hover during the first two days; then a little farther away each day, and down onto the house floor about the fourth or fifth day, if the weather is not too cold. They must not get cold enough to huddle or cry, but must come out from under the hover frequently.

The floor of the brooder is cleaned every day and kept well sprinkled with sharp, fine crushed rock, known in the market as "chicken grit." The floor of the house is covered with clover leaves or with hay chaff from the feeding floor in the cattle barns.

FEEDING THE CHICKS.

Until recently the young chicks were fed bread made by mixing 3 parts of corn meal, 1 part wheat bran, and 1 part wheat middlings or flour with skim milk or water, mixing it very dry and salting as usual for bread. It was baked thoroughly, and when well done, if it was not dry enough to crumble, it was broken up and dried out in the oven and then ground in a mortar or mill. The infertile eggs were hard boiled and ground, shell and all, in a sausage mill. About 1 part of ground egg and 4 parts of the bread crumbs were rubbed together until the egg was well divided. This bread made up about one-half of the food of the chicks until they were 5 or 6 weeks old. Eggs were always used with it for the first one or two weeks, and then fine-sifted beef scrap was mixed with the bread.

The use of bread has been given up, not because there is anything better for the young chicks, but because experiments with other methods of feeding led to the conclusion that equally good results could be obtained in other ways and with less labor. The method of feeding now used for chicks is as follows: Infertile eggs are boiled for half an hour and then ground in an ordinary meat chopper, shells included, and mixed with about six times their bulk of rolled oats by rubbing both together, enough to break the egg into small pieces. This mixture is the feed for two or three days, until the chicks have learned how to eat. It is fed sparingly, in the litter and sand on the brooder floor. When the chicks are about 4 days old they are fed a mixture of hard, fine-broken grains—i. e., cracked corn, wheat, millet, and pin-head oats—as soon as the birds can see to eat in the mornings. This is fed in the litter, being careful to limit the quantity so they will be hungry at 10 o'clock. Several of the prepared dry chick feeds have been used and found satisfactory when they are made of good clean grains and do not contain grit. The grit and charcoal can be supplied at less cost, and must be freely provided.

At 10 o'clock the rolled oats and egg mixture is fed in tin plates with low rims. After the chicks have had the feed before them five minutes the dishes are removed, and they have nothing to lunch on

except a little of the fine-broken grain, which they scratch for. At 1 o'clock the hard grains are again fed as in the morning, and at 4.30 to 5 o'clock the chicks are fed on the rolled oats and egg mixture, being given all they will eat until dark.

When the chickens are about 3 weeks old the rolled oats and egg mixture is gradually displaced by a mixture made up of 2 parts, by weight, of good clean bran, 2 parts corn meal, 1 part middlings or "red dog" flour, 1 part linseed meal, and 1 part fine beef scrap. This mixture is slightly moistened, but not enough to make it sticky, as it should crumble when a handful is squeezed and then released. By this time the birds are developed far enough to dispense with the tin plates, which are replaced by light flat troughs with low sides.

The hard, broken grains may be safely used all the way along and the fine meals left out, but the chicks do not grow so fast as when the mash is fed. There seems, however, to be least danger from looseness of the bowels when only the dry grains are fed. It is very essential that the mash be dry enough to crumble in order to avoid that difficulty. Young chicks like the moist mash better than a dry mixture and will eat more of it. There is no danger from freely using the properly made mash twice a day, and being made up largely of finely ground material the young birds can eat and digest more of it than when the food is all coarse. This is a very important fact and should be taken advantage of at the time when the young things are most susceptible to rapid growth. But the development must be moderate during the first few weeks. The digestive organs must be kept in normal condition by the use of some hard foods, and the gizzard must not be deprived of its legitimate work and allowed to become weak by disuse.

Clean water, charcoal, granulated bone, oyster shell, and sharp grit are always kept by them. Mangolds are cut into slices, which the chicks soon learn to peck. When the grass begins to grow they are able to get green food from the yards. If the small yards are worn out before they are moved to the range, cut green clover or rape is fed to them.

FEEDING CHICKENS ON THE RANGE.

By the middle of June the chickens that were hatched in April are being fed on cracked corn, wheat, and the mash. At about that time the portable houses with their contents of chickens are drawn from their winter locations out to an open hayfield where the crop has been harvested and the grass is short and green. (See pl. 2.) If not too much worn, the same field may be used a second season for chickens, but this is not recommended. A new, clean piece of turf land should be used each year. Two acres should be allowed for each 1,000 chickens.

When the chickens are moved to the range the sexes are separated. The methods of feeding the cockerels and pullets differ, and there has been a gradual change in the methods of feeding. Each method has given good results. The changes have been introduced to save labor. After the chickens were moved to the range they were fed in the morning and evening with a moistened mixture of corn meal, middlings, and wheat bran, to which one-tenth as much beef scrap was added. The other two feeds were of wheat and cracked corn.

In 1904 a change was made in the manner of feeding 1,400 female chickens by omitting the moist mash and keeping in separate slatted troughs cracked corn, wheat, beef scrap, cracked bone, oyster shell, and grit where they could help themselves whenever they desired to do so. Grit, bone, and oyster shell were always supplied. There were no regular hours for feeding, but care was taken that the troughs were never empty.

In 1905 another trough containing a dry mash consisting of 1 part wheat bran, 2 parts corn meal, 1 part middlings, and 1 part beef scrap was used in addition to those containing the grains. The results were satisfactory. The labor of feeding was far less than that required by any other method tried. The birds did not hang around the troughs and overeat, but helped themselves, a little at a time, and ranged off, hunting or playing, and coming back again to the food supply at the troughs when so inclined. There was no rushing or crowding about the attendant, as is usual at feeding time where large numbers are kept together. While the birds liked the beef scrap, they did not overeat of it. During the range season, from June to the close of October, the birds ate just about 1 pound of the scrap to 10 pounds of the cracked corn and wheat. This is practically the proportion eaten when the moist mash was used.

THE FEEDING TROUGH.

The difficulty of keeping the feed clean and dry during continued exposure is nearly overcome by using troughs with slatted sides and broad detachable roofs (figs. 1 and 2). The troughs are from 6 to 10

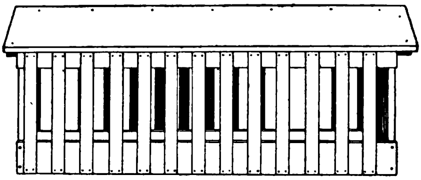


FIG. 1.—Chicken feeding trough, accessible from both sides, with cover on.

feet long, with the sides 5 inches high. The lath slats are 2 inches apart, and the troughs are 16 inches high from floor to roof. The

roofs project about 2 inches at the sides and effectually keep out the rain except when high winds prevail.

The roof is very easily removed by lifting one end and sliding it endwise on the opposite gable end on which it rests, as shown in figure 2. The trough can then be filled and the roof drawn back into

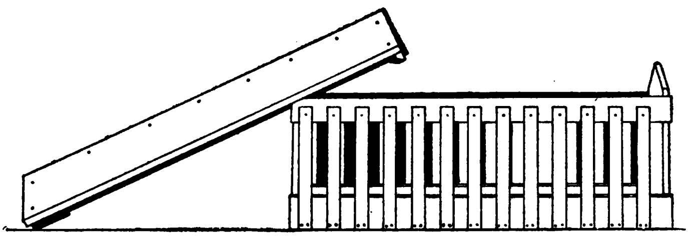


FIG. 2.—Chicken feeding trough with cover removed.

place without lifting it. This arrangement is economical of feed, keeping it in good condition and avoiding waste. When dry mash is used there may be considerable waste by the finer parts being blown away, and on this account the dry mash trough should be put in a sheltered place out of the reach of wind.

FEEDING THE COCKERELS FOR MARKET.

At the Maine Station most of the cockerels are to be used for breeding purposes, and they are fed in flocks of about 100 on the range in about the same way as the pullets. The dry-feed method is now used for them as satisfactorily as for the pullets.

A very large proportion of the cockerels raised in New England are sent to the market alive, without being fattened. Quite extended experiments at the Maine Station with many birds, in different years, indicate very clearly that keeping the cockerels for a few weeks with special feeding will add materially to the selling price. Not infrequently this will make the difference between loss from the low price obtained for slow-selling unfattened birds and the profit from comparatively quick-selling specially fed birds at a much higher price. The higher price is due partly to the increased weight and partly to the superior quality of the well-covered soft-fleshed chickens. As the bulletins containing the results of these feeding experiments with cockerels are out of print, the following brief summary of the results obtained is given:

The number of pounds of grain required to produce 1 pound of gain in fattening cockerels was ascertained in experiments comparing the effect of housing, the effect of age, and the effect of skim milk. The grain mixture used in these series of experiments was the same, consisting of 100 pounds of corn meal, 100 pounds of wheat middlings, and 40 pounds of meat meal. This was fed as a porridge thick enough to drop but not to run from a spoon.

The French and English fatteners who make a specialty of the business, fattening thousands of chickens each year, confine the chickens in small coops. Coops used at the Maine Experiment Station gave a floor space of 16 by 23 inches. They were constructed of laths with closed-end partitions of boards. The floors, sides, and tops were of laths placed three-quarters of an inch apart. By simply moving the pens thus constructed the floors were kept clean. V-shaped troughs with 3-inch sides were placed in front and about 2 inches above the level of the floors of the coops. Cockerels thus fed were compared with others kept in small houses 9 by 11 feet in size, with an attached yard 20 feet square. The yard was entirely free from anything that would serve as green food. Twenty birds were put in each of these houses.

As a result of experiments with fattening 286 birds it was found that on the average 7.9 pounds of grain were required to produce 1 pound of gain in the case of birds fed in the coops, and 5.9 pounds in the case of those fed in the small houses and yards.

An experiment with 150 birds when they were 4 months old showed that they required 4.9 pounds of grain to produce 1 pound of gain, while birds from the same stock, when they were 6 months old, required 7.4 pounds of grain to produce 1 pound of gain.

An experiment with 68 birds showed that when the porridge was wet with skim milk only 4.3 pounds of grain were required to produce 1 pound of gain, against 5.3 pounds when the porridge was wet with water. Eight pounds of skim milk was used with each pound of grain.

These experiments warrant the following conclusions: As great gains are made just as cheaply and more easily when the chickens are put into small houses and yards as when they are fed in small lots in lattice coops just large enough to hold them. Four weeks is about the limit of profitable feeding, both individually and in flocks. Chickens gain faster while young. Birds that are from 150 to 175 days old have uniformly given comparatively small gains. The practice of successful poultrymen selling chickens at the earliest marketable age is well founded. The spring chicken sold at Thanksgiving time is an expensive product. The experiments clearly indicate that it is profitable to fatten chickens in cheaply constructed sheds or in large coops with small runs for about four weeks and then send them to market dressed. In quality the well-covered, soft-fleshed chickens are so much superior to the same birds not specially prepared that the former will be sought for at a higher price. The dairy farmer is particularly well prepared to carry on this work, as he has the skim milk which these experiments show to be of so great importance in obtaining cheap rapid growth and superior quality of flesh.

HOUSING THE HENS.

When work in poultry management was first undertaken at the University of Maine the hens were kept in small colonies in accord with what was at that time believed to be the best practice. Houses 10 feet square were erected with the idea of accommodating about 15 birds each. They were well warmed and yet were apt to be damp and lined with white frost in very cold weather when the windows had to be kept shut to protect the birds from cold at night. Another disadvantage of this kind of house is its small size. A person can not care for hens in such small pens without getting them into a condition of unrest for fear of being cornered in such a small room. The question of extra labor in caring for hens in these small colonies scattered over quite a large area is an important factor in a commercial plant. When the Maine Experiment Station began experiments in 1897 a warmed house 150 feet long by 16 feet wide was erected. As before mentioned, this house was burned the next spring, but was replaced.

THE WARMED HOUSE.

This house (designated as No. 1 and illustrated in pl. 3), which was erected in 1898, is 16 feet wide by 150 feet long. It faces the south and conforms nearly to the land surface, the east end being 3 feet 6 inches lower than the west end. The sills are of 4 by 6 inch hemlock, placed flat upon a rough stone wall which rests upon the ground surface and varies from 1 to 2 feet in height. The earth is graded up to within 6 inches of the sills on the outside. The floor timbers are 2 by 8 inches, placed 2 feet 6 inches apart, and rest on the sills. The studs for the back wall are 2 by 4 inch joists, 5 feet 8 inches long, and rest on the sills. The front studs are 10 feet 6 inches long. All the studs are set 3 feet apart. Each 10 feet in length of the front of the building has one 12-light window of 10 by 12 inch glass. The top of this window comes within 1 foot of the plate. Directly underneath these windows and 6 inches above the floor are other 3-light windows of 10 by 12 inch glass. The building is boarded, papered, and shingled all over the outside, both roof and walls. The floor is of two thicknesses of hemlock boards. The entire inside of the building is papered on the studs and rafters and sheathed with matched boards. The work was carefully done and good dead-air spaces were obtained over the whole building.

The house is divided into fifteen 10-foot sections. The close partitions between the pens are 2 feet high and are made of 2-inch plank. They form strong trusses, to which the studs supporting the central plate are strongly nailed. This saves the floor from sagging from the weight of the roof when it is covered with snow. An elevated plank walk 4 feet wide runs along inside the whole length of the front of

the building and rests on the cross partitions just mentioned. The walk is 2 feet 6 inches above the floor, thus allowing the hens to pass under it and occupy the whole floor space. This part of the floor is lighted from the front by the small windows before mentioned. Above the close partition the pens are separated from each other and the walk by wire netting of 2-inch mesh. Light wooden-frame doors, covered with wire and hung with double-action spring hinges, are in every cross partition, and also in the partitions between the elevated walk and each pen.

The back ends of the cross partitions, 4 feet out from the back wall, are carried up to the roof, so as to protect the hens from currents of air while on the roosts. The roost platform is along the back wall. Four trap nests (described on page 36) are placed at the back of the house at the end of the roost platform in each pen.

All the windows are double; eight of the large outside ones are hinged at the top and kept hasped out 1 foot at the bottom, except in the roughest weather and on cold winter nights. This furnishes ventilation without drafts, as the position of the outside windows prevents strong currents of air from entering.

Although this house was thoroughly built, it was found necessary to close the windows during rough winter weather or water would freeze quite hard inside the building. Closing the windows caused dampness and frost on the walls, and the straw litter absorbed the moisture and became while yet clean disagreeable to the hens. A hot-water heater was placed in a pit at the lower end of the building, and one line of 2-inch pipe was carried under the roosts to the upper end of the building and returned to the boiler. By use of this heater the building is kept above the freezing point at all times, and there is not much trouble from moisture except when extremely cold weather necessitates the closing of the windows.

The birds in this house have always been in excellent health and have never shrunk in their egg yields from cold weather, except in one season when coal was not procurable and the temperature ran low.

The ease with which the hens are cared for, the availability of the entire floor space, and the welfare and productiveness of the birds kept here commend this building as one of the best. It was planned and constructed so as to obtain conditions believed to be necessary for the welfare of the birds and to economize the labor involved in their care. While a single-walled building would have cost less, it would not have kept the hens warm or given protection from the dampness which prevails in close single-walled houses.

THE ROOSTING-CLOSET HOUSE.

Five years ago one of the 10-foot square houses described above was taken for a nucleus and an addition made, so that the reconstructed

POULTRY HOUSES.

The small house at the left is a brooder house. The other houses are, from left to right, poultry houses Nos. 1, 2, and 3.

house was 10 feet wide and 25 feet long (pl. 1, fig. 2). The inside end of the old house was taken out, so that there is one room with a floor space of 250 square feet. The walls are about 5½ feet high in the clear inside of the building. The whole of the front wall is not filled in, but a space 3 feet wide and 15 feet long is left just under the plate. This space had a frame covered with white drilling, hinged at the top on the inside, so it can be let down and buttoned during driving storms and winter nights, but hung up out of the way at all other times. The cloth of the outer curtain is oiled with hot linseed oil. The roost platform extends the whole length of the back of the room. It is 3 feet 4 inches wide and 3 feet above the floor. The back wall and up the roof for 4 feet is lined and the space filled and packed hard with fine hay. The packing also extends part way across the ends of the room.

Two roosts are used, but they do not take the whole length of the platform, a space of 4 feet at one end being reserved for a crate where broody hens can be confined until the desire for sitting is overcome. The space, from the front edge of the platform up to the roof, is covered by frame curtains of drilling, similar to the one on the front wall except that it is not oiled. They are hinged at the top edge and kept turned up out of the way during daytime, but from the commencement of cold weather until spring they are closed down every night after the hens go to roost. The hens are shut in this close roosting closet and kept there during the night, and are released as early in the morning as they can see to scratch for the grain which is sprinkled in the 8-inch deep straw on the floor.

The roosting closet has been closely observed and has never been damp or its odors offensive when opened in the mornings. There was very little freezing in the closets in the coldest weather. The birds seemed to enjoy coming out of the warm sleeping closet down into the cold straw, which was always dry, because the whole house was open to the outside air and sun every day. There were no shut-off corners of floor or closet that were damp. This building has been used through five winters with 50 hens in it. The birds have laid as well as the others in the large warmed house; their combs have been red and their plumage bright, and they have given every evidence of perfect health and vigor. While they are on the roosts they are warm. They come down to their breakfasts and spend the day in the open air. Such treatment gives vigor and snap to the human being, and it seems to work equally well with the hen.

This house, which was given the name of the "pioneer" house, is shown in plate 1, figure 2.

CURTAIN-FRONT HOUSES.

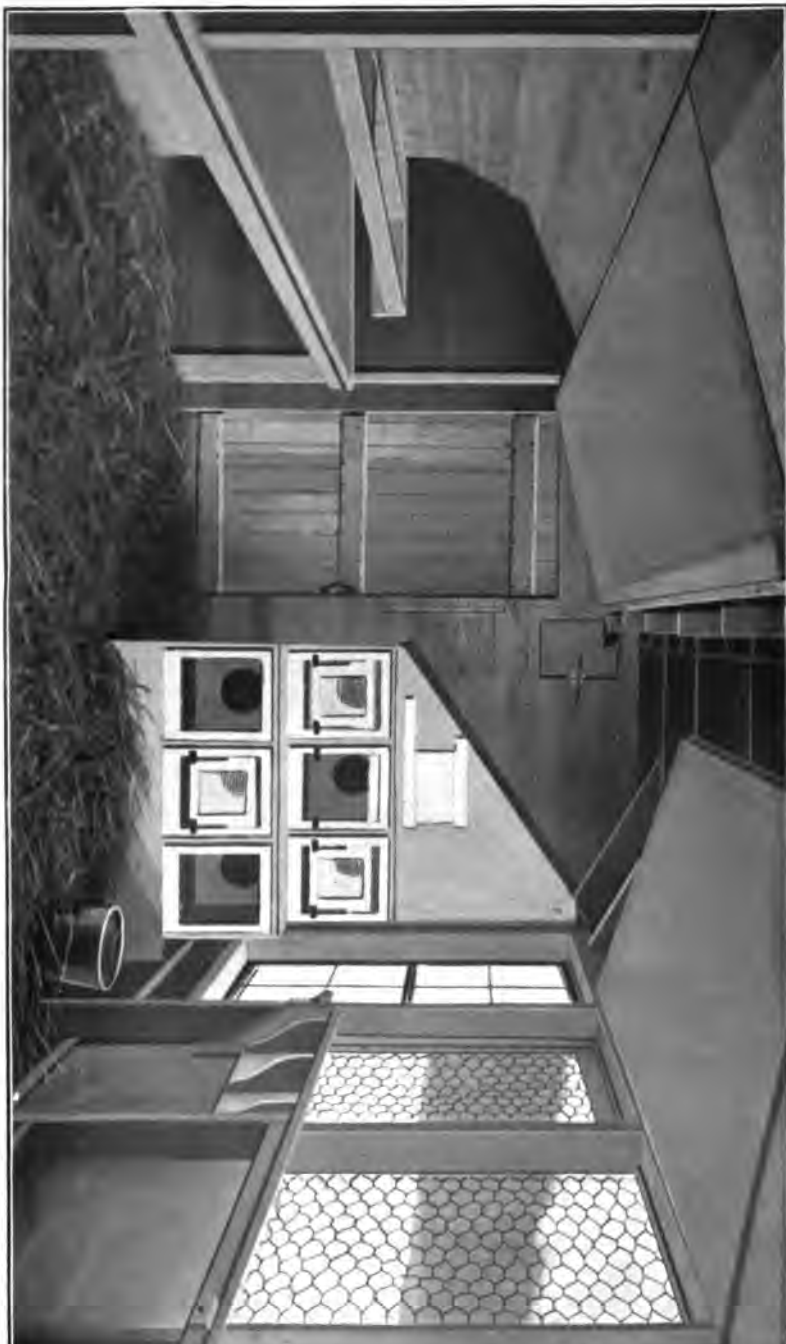
The result of the use of the "pioneer" house indicated that this was one of the right systems of treatment and housing of hens, and it

was decided to build several houses on the same plan and join them together under one roof as one house.

A curtain-front house 12 feet wide by 150 feet long, known as house No. 2 (pls. 3 and 4), was erected in 1903. The back wall is 5 feet 6 inches high from floor to top of plate inside, and the front wall is 6 feet 8 inches high. The roof is of unequal span, the ridge being 4 feet in from the front wall; and the height of the ridge above the floor is 9 feet. The sills are 4 by 6 inches in size and rest on a rough stone wall laid on the surface of the ground. A central sill gives support to the floor, which at times is quite heavily loaded with sand. The floor timbers are 2 by 8 inches in size and are placed 2 feet apart; the floor is of two thicknesses of hemlock boards. All the rest of the frame is of 2 by 4 inch stuff. The building is boarded, papered, and shingled on roof and walls. The rear wall and 4 feet of the lower part of the rear roof are ceiled on the inside of the studding and plates, and the space between inner and outer walls is packed very hard with dry sawdust. In order to make the sawdust packing continuous between the wall and roof, the wall ceiling is carried up to within 6 inches of the plate; then follows up inclining pieces of studding to the rafters, the short pieces of studding being nailed to the studs and rafters. By this arrangement there are no slack places around the plate to admit cold air. The end walls are packed in the same way. The house is divided by close-board partitions into seven 20-foot sections; one 10-foot section is reserved at the lower end for a feed-storage room.

Each of the 20-foot sections has two 12-light outside windows screwed onto the front, and the space between the windows (which is 8 feet long) for a distance of 3 feet down from the plate is covered during rough winter storms and cold nights by a light frame covered with 10-ounce duck, oiled, and closely tacked on. This door, or curtain, is hinged at the top and swings in and up to the roof when open.

In the front of each section is a door 2 feet 6 inches wide. The roost platform is at the back of each room and extends the whole 20 feet. The platform is 3 feet 6 inches wide and 3 feet above the floor. The roosts are of 2 by 3 inch stuff placed on edge and are 10 inches above the platform. The back one is 11 inches out from the wall, and the space between the two roosts is 16 inches, leaving 15 inches between the front roost and the duck curtain, which is sufficient to prevent the curtain being soiled by the birds on the roost. The two curtains in front of the roost are similar to the one in the front of the house, except that they are not oiled. They are each 10 feet long by 30 inches wide, hinged at the top, and open into the room and fasten up when not in use. Great care was exercised in constructing the roosting closets to have them as nearly air-tight as possible, except as air might come in through the cloth curtain.



INTERIOR OF CURTAIN-FRONT POULTRY HOUSE NO. 2.

Single pulleys are hung at the rafters, and, by means of a rope fastened to the lower edge of the curtain frames, it is easily raised or lowered and kept in place. At one end of the roosts a space of 3 feet is reserved as a cage for broody hens. This being behind the curtain, the birds have the same night temperature when they are transferred from the roosts to the cage.

Six trap nests are placed at one end of each room and four at the other. They are put near the front so that the light may be good for reading and recording the numbers on the leg bands of the birds. Several shelves are put on the walls 18 inches above the floor for shell, grit, bone, etc. The doors which open from one room to another throughout the building are frames covered with 10-ounce duck, so as to make them light, and are hung with double-action spring hinges. The advantages of having all doors push from the person passing through are very great; otherwise they would hinder the passage of the attendant with his baskets and pails. Strips of old rubber belting are nailed around the studs which the doors rub against as they swing to, so as just to catch and hold them from being opened by the wind. Tight board partitions are used between the pens instead of wire, so as to prevent drafts. An outside platform 3 feet wide extends across both ends and the entire front of the building.

This house accommodates 350 hens—50 in each 20-foot section—is well made of good material, and should prove to be durable. A rougher building, with plain instead of trap nests, and with the roof and walls covered with some of the prepared materials instead of shingles, could be built for less money, and would probably furnish as comfortable quarters for the birds.

Curtain-front house No. 3 (pl. 3) was constructed in 1904. It is 16 feet wide by 120 feet long, and is of the same style as No. 2, except that it is wider. There are four pens in the building, each 16 feet wide by 30 feet long. Two of the pens are arranged for 100 hens each, and two for 150 each. For the 150 hens three roosts instead of two are required.

The cloth-covered fronts of the closets where 100 and 150 hens roost are of the same size, and it became evident early in the first winter that the supply of fresh air to the largest flock was not sufficient. It was not practicable to increase materially the cloth surface and allow more air to filter in, so three openings were made in the upper part of the curtain frame, through which better ventilation could be secured. The openings are 6 inches wide by 30 inches long and are provided with wooden shutters. These are kept wide open into the outer room during mild nights, but when high winds prevail and the temperature falls to 10 or more degrees below zero the openings are half closed.

The walls of the elevated closet are packed with sawdust 4 inches in thickness, and the curtains fit very closely, leaving only small cracks.

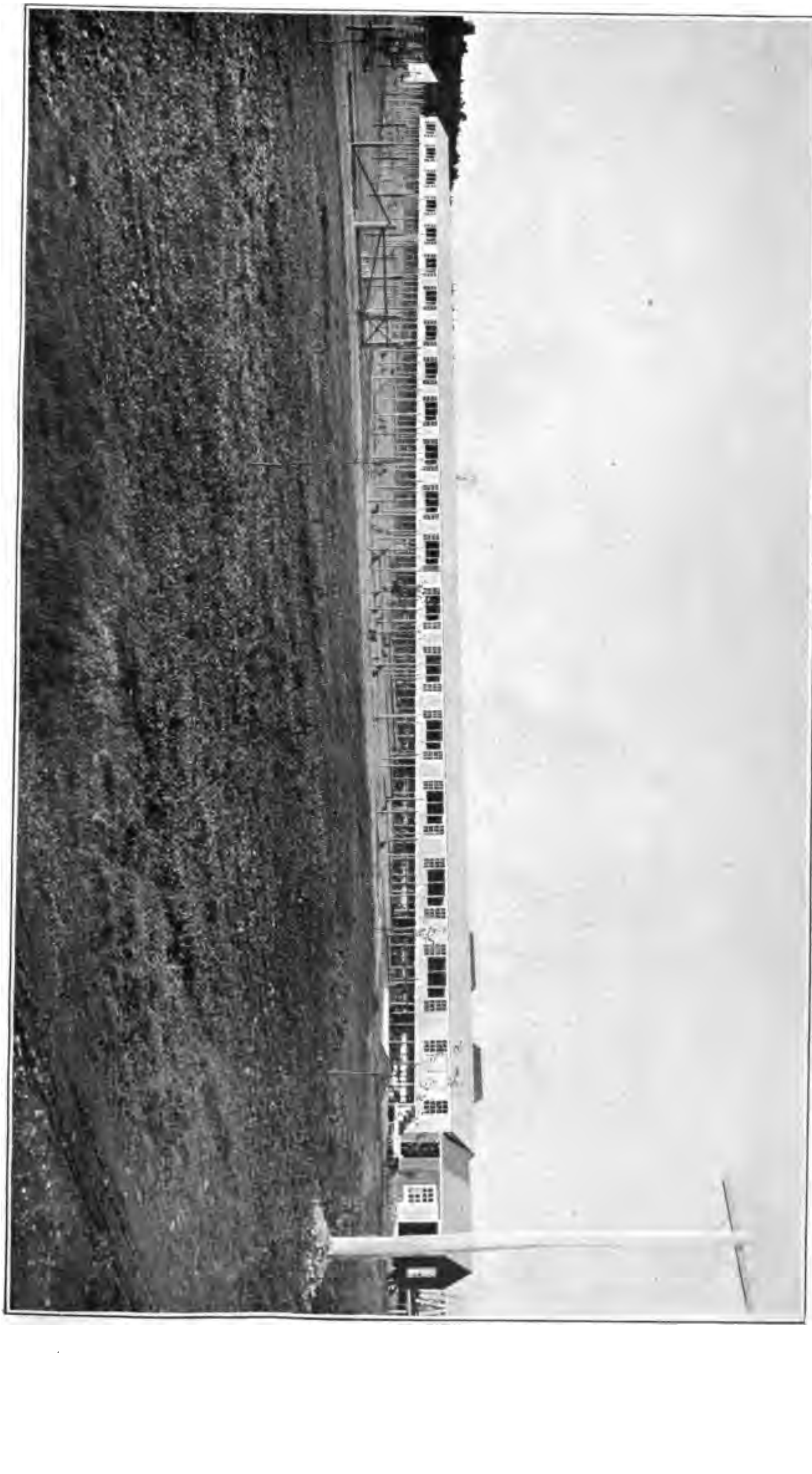
The 10-ounce duck of which the curtains are made is not oiled. The supply of fresh air is mostly admitted through the cloth, while the breathed warmer air passes off through the openings above. By this arrangement the birds are not in drafts or currents of air. Where three roosts are arranged abreast, instead of two, the openings are absolutely essential, and for smaller flocks they are convenient during the mild nights, especially toward spring.

THE LATEST FORM OF CURTAIN-FRONT HOUSE.

During the summer of 1905 the management of a commercial poultry plant in Orono built a curtain-front house to accommodate 2,000 laying hens. This was built in accordance with unpublished plans prepared by the Maine Experiment Station. The description is here given as it represents the latest development of this style of house (pl. 5).

The house is 20 feet wide by 400 feet long, and is divided into 20 sections, each being 20 feet square. It is on the same general plan as houses Nos. 2 and 3 just described, but house No. 2 is 12 feet wide, house No. 3 16 feet wide, and this one 20 feet wide. The widths have been increased in the last two houses, as experience has shown the advisability of it. At first it was thought the houses should be narrow so they might dry out readily, but the 20-foot house dries out satisfactorily, as the opening in the front is placed high up so that the sun shines in on the floor to the back in the shortest winter days.

The economy in the cost of the wide house over the narrow ones, when space is considered, is evident. The front and back walls in the narrow house cost about as much per lineal foot as those in the wide house, and the greatly increased floor space is secured by building in a strip of floor and roof running lengthwise of the building. The carrying capacity of a house 20 feet wide is 66 per cent greater than that of a house 12 feet wide, and it is secured by merely building additional floor and roof. The walls, doors, and windows remain the same as in the narrow house, except that the front wall is made a little higher. Three sills which are 6 inches square run lengthwise of the house, the central one supporting the floor timbers in the middle. They rest on a rough stone wall, high enough from the ground for dogs to go under the building to look after rats and skunks that might incline to make their homes there. The stone wall rests on the surface of the ground, and there are openings in it like cellar windows every 20 feet to allow the air to draw through and keep the basement dry during the summer. The floor timbers are 2 by 8 inches in size and rest wholly on top of the sills. All wall studs rest on the sills; the front ones are 8 feet long, and the back ones 6 feet 6 inches long. The two sides of the roof are unequal in width, the ridge being 8 feet from the front wall. The height of the ridge from the sill to the extreme top is 12 feet 6 inches. All studding is 2 by 4 inches in size and the rafters are



The Latest Curtain-front Poultry House.

2 by 5 inches. The building is boarded with 1-inch boards, and is papered and shingled with good cedar shingles on walls and roof. The floor is of two thicknesses of hemlock boards which break joints in the laying.

The building is divided by tight board partitions into twenty sections, each section being 20 feet long. All of the sections are alike in construction and arrangement. The front side of each section has two storm windows of twelve lights of 10 by 12 inch glass. These windows are screwed on upright and 2 feet 8 inches from each end of the room; they are 3 feet above the floor. The distance between the windows is 8 feet 10 inches, and the top part of it to a depth of 3 feet 6 inches from the plate is not boarded but is left open to be covered by the cloth curtain when necessary. This leaves a tight wall 3 feet 10 inches high extending from the bottom of the opening down to the floor, which prevents the wind from blowing directly on the birds when they are on the floor. A door is made in this part of the front wall for the attendant to pass through when the curtain is open. A door 16 inches high by 18 inches wide is placed close to the floor under one of the windows for the birds to pass through to the yards in front. A similar door is in the center of the back wall to admit them to the rear yard when it is used.

A light frame made of 1 by 3 inch pine strips and 1 by 6 inch crossties is covered with 10-ounce white duck and hinged at the top of the front opening, which it covers when closed down. This curtain is easily turned up into the room, where it is caught and held by swinging hooks until released.

The roost platform is made tight and extends along the whole length of the room against the back wall. It is 4 feet 10 inches wide and 3 feet above the floor, being high enough for a person to get under it comfortably when necessary to catch or handle the birds. There are three roosts framed together in two 10-foot sections. The tops of the roosts are 1 foot above the platform and hinged to the back wall, so they may be turned up out of the way when the platform is being cleaned. The back roost is 12 inches from the wall, and the spaces between the next two are 16 inches. They are made of 2 by 3 inch spruce lumber placed on edge with the upper corners rounded off. The roosting closet is shut off from the rest of the room by curtains similar to the one described above. For convenience in handling there are two of these curtains, each 10 feet long. They are 3 feet wide and are hinged at the top so as to be turned out and hooked up. The space above this curtain is ceiled and in it are two openings each 3 feet long and 6 inches wide for ventilating the roosting closet when necessary. In every compartment there is a door placed 5 inches out from the edge of the roost platform. These doors are 3 feet wide and 7 feet high, divided in the middle lengthwise, and each half is

hung with double-acting spring hinges allowing it to swing open both ways and close.

Ten nests are placed, in two tiers, against the partition in each end of the room. They are of ordinary form, each nesting space being 1 foot wide, 1 foot high, and 1 foot long, with the entrances near the partition, away from the light, and with hinged covers in front for the removal of the eggs. Each section of 5 nests can be taken out without disturbing anything else, cleaned, and returned. In constructing the house it was designed to use these nests only during the present year. The framework where they rest was arranged for the use of trap nests, the intention now being to install them in October of the present year (1906).

Troughs similar to those described on page 24 are used for feeding dry mash, shell, bone, grit, and charcoal.

Two lines of 4 by 4 inch spruce are arranged as an elevated track above the doors. The track extends the entire length of the building, and being faced with narrow steel bands on top, a suspended car is readily pushed along, even when heavily loaded. The car platform is 2 by 8 feet in size, and is elevated a foot above the floor. All feed and water are carried through the building on this car. Ten iron baskets, into which the accumulations on the roost platforms are cleaned every morning, are put on the car, and collections are made as the car passes on through the pens to the far end of the building, 400 feet away, where the roost cleanings are dumped into the manure shed. As the car is pushed along a guard at the front end comes in contact with the doors and pushes them open, and they remain open until the car has passed on, when the spring hinges force them to close again. This car is a great saver of labor, as it does away with nearly all carrying by the workmen. It has enabled one man to take good care of the 2,000 hens from November to March, except on Saturdays, when the litter has been removed and renewed by other men.

At one end of the building there is a temporary feed and water house, also used for dish washing and scalding, where the car remains when not in use.

There is a walk outside of the building, extending along its entire front. It is 4 feet wide, made of 2-inch plank, and is elevated 2 feet above the floor of the building, which allows the doors below it, through which the birds pass to the front yards, to be opened and closed without interference. The door which opens out of each room through the curtain section is above the outside walk and necessitates stepping up or down when passing through, which is not a very serious objection, as the door is used but little in the daily work, but mostly in the weekly cleaning out and renewing of the floor litter. A guard of wire poultry netting 1 foot wide, along the outside of the walk, prevents

the birds from flying from the yards up to the walk. The advantage of the elevated walk over one on a level with the sill of the building is that it is unobstructed by gates, which, were the low walk used, would be necessary to prevent the birds from passing from one yard to another.

SATISFACTORY RESULTS WITH CURTAIN-FRONT HOUSES.

The "pioneer" house has been in use for five years with 50 pullets in it each year, the No. 2 house three years with 300 pullets each year, the No. 3 house two years, and the house last described one year. Besides these four houses, the Maine Station has had the use of another house of the open-front style of construction for four years with about 200 1-year-old breeding hens in it each year.

Maine is subject to long spells of severe cold weather, with the temperature considerably below zero at night, and about zero during the day, and with a good deal of high wind. During such rough weather the bedding on the floor has kept comparatively dry; and the voidings on the platform, when the curtains are raised in the mornings, have been but slightly frozen. The yields of eggs during severe weather and immediately following it are rarely below those immediately preceding it. It should be borne in mind that had the weather been mild all that time the hens probably would have increased in production rather than remained stationary. They are doubtless affected by the severe weather, but not seriously, as they uniformly begin to increase in production very soon after the weather becomes normal for midwinter.

These curtain-front houses have all proved eminently satisfactory. Not a case of colds or snuffles has developed from sleeping in the warm elevated closets, with their cloth fronts, and then going directly down into the cold room, onto the dry straw, and spending the day in the open air. The egg yields per bird have been as good in these houses as in the warmed ones. The purpose of having rooms and flocks of different sizes was to compare the results of the welfare and egg yields of the birds under the different conditions.

THE YARDS.

The yards to most poultry houses are at the south, or on the sheltered sides of the buildings, to afford protection during late fall and early spring, when cold winds are common. The warmed house has yards on both north and south sides, with convenient gates. The south yards are used until the cold winds are over in spring, when the hens are allowed to go to the north yards, which are well set in grass sod. With the curtain-front houses the yards are on the north side only. The birds are kept in the building until the weather is suitable for opening the small doors in the rear wall. The necessity for getting

them out of the open-front house, where they are really subject to most of the out-of-door conditions during the daytime, is not so great as when they are confined in closed houses with walls and glass windows. The clear, open fronts of the curtain-front houses allow teams to pass close to the open door of the pens for cleaning out worn material and delivering new bedding, and also allow attendants to enter and leave all pens from the outside walk and reach the feed room without passing through intervening pens.

TRAP NESTS.

The trap nest in use at the Maine Station is original with this station. It is very simple, inexpensive, easy to attend to, and certain in its action. It is a box-like structure, without front, end, or cover, 28 inches long, 13 inches wide, and 16 inches deep, inside measure. A division board with a circular opening 7½ inches in diameter is placed across the box 12 inches from the rear end and 15 inches from the front end. The rear section is the nest proper. Instead of a closely made door at the entrance, a light frame of 1 by 1½ inch material is covered with wire netting of 1-inch mesh. The door is 10 inches wide by 10 inches high, and does not fill the entire entrance, a space of 2 inches being left at each side, to avoid friction. It is hinged at the top and opens up into the box. The hinges are placed on the front of the door rather than at the center or rear, the better to secure complete closing action. The trap consists of one piece of stiff wire about three-sixteenths of an inch in diameter and 22 inches long. This piece of wire is shaped so that a section of it, 11 inches long, rests directly across the circular opening in the division board, and is held in place by two loosely fitting clamps, the slots being long enough to allow the wire to work up and down about 3 inches. The next section of the wire is 8 inches long, and it is bent so that it is at right angles with the 11-inch section. It passes along the side of the box 11 inches above the floor, back toward the entrance door, and is fastened strongly to the wall by staples, but yet loosely enough so that the wire can roll easily. The remaining section of the wire, which is 3 inches long, is bent toward the center of the box, with an upward inclination, so that it supports the door when it is open and rests upon it. The end of the wire is turned over smoothly, forming a notch into which the door may slip when opened.

As the hen passes in under the open door and then through the circular opening to the nest, she raises herself so that her keel may pass over the lower part of the division board; at the same time her back presses against the horizontal wire as she passes it, and lifts it so that the end supporting the door slides from under it. Thus released, the door swings down and passes a wire spring near the bottom of the box at the entrance, which locks it and prevents the hen from escaping and others from entering.

The trap nests are placed four or more in a block, slide in and out like drawers, and can be carried away for cleaning when necessary. Four nests in a pen accommodate 20 hens, by the attendant going through the pens once an hour, or a little oftener, during that part of the day when the hens are busiest. Earlier and later in the day his visits are not so frequent. The double box with the nest in the rear is necessary. When a hen has laid an egg, and desires to leave the nest, she steps out into the front space and remains there until she is released. With only one section she would be likely to crush her egg by stepping upon it, and thus learn the pernicious habit of egg eating.

To remove a hen the nest is pulled part way out, and, as it has no cover she is readily caught, the number on her leg band is noted, and the proper entry is made on the record sheet. After having been taken off a few times the hens do not object to being handled; most of them remaining quiet, apparently expecting to be picked up.

Before commencing the use of trap nests it was thought that some hens might be irritated by the trapping operation and object to the noise incident to it, but such does not seem to be the case. The trap nests have been used at the Maine Station for Leghorns, Brahmas, Wyandottes, and Plymouth Rocks.

The amount of time required in caring for the trap nests can only be estimated, since the attendant's time is divided with other duties. The time varies from one day to another and with the number of nests in use. By noting the total time used each day in caring for the nests when the hens were laying most heavily, it has been estimated that one active person devoting his entire time to trap nests could take care of 400 to 500 nests used by 2,000 to 2,500 hens. When commencing the year's work he would need assistance in banding the birds, but after that was done he could care for the nests without assistance until midsummer, when the egg yields would probably be diminished and a part of his time could be spared for other duties.

FEEDING THE HENS.

For about twenty-five years the same family of Barred Plymouth Rocks has been carried at the University of Maine, and one way has been learned to feed and handle them to secure eggs and to avoid the losses from overfatness which are so common to mature hens of that breed. It is not claimed or thought that the methods of feeding here given are ideal; other methods may be as good or even better. These methods have, however, given good results at the Maine Station. While it is true that only the full-fed hen can lay to the limit of her capacity, it is equally true that full feeding of the Plymouth Rocks, unless correctly done, results disastrously.

Years ago the "morning mash," which was regarded as necessary to "warm up the cold hen" so she could lay that day, was given up,

and the mash was fed at night. The birds for several years prior to 1903 were fed daily throughout the year as follows: Each pen of 22 received 1 pint of wheat in the deep litter early in the morning. At 9.30 a. m. one-half pint of oats was fed to them in the same way. At 1 p. m. one-half pint of cracked corn was given in the litter as before. At 3 p. m. in winter and 4 p. m. in summer they were given all the mash they would eat up clean in half an hour.

The mash was made of the following mixture: 200 pounds of wheat bran, 100 pounds of corn meal, 100 pounds of wheat middlings, 100 pounds of linseed meal, 100 pounds of gluten meal, and 100 pounds of beef scrap. The mash was used with one-fourth its bulk of clover leaves and heads obtained from the feeding floor in the cattle barns. The clover was covered with hot water and allowed to stand for three or four hours. The mash was made quite dry, and rubbed down with the shovel in mixing, so that the pieces of clover were mixed in and became covered with the meal.

Cracked bone, oyster shell, grit, and water were placed before the chickens all the time. In winter two large mangolds were fed daily to the birds in each pen. They were stuck onto large nails which were partly driven into the wall a foot and a half above the floor.

Very few soft-shelled eggs were laid, and so far as known not an egg has been eaten by the hens thus fed.

The records of several years' feeding show that from 50 to 55 pounds of the dry materials of which the mash was made up were eaten by each hen in a year. The quantity of grain fed in the litter was the same every day, winter or summer. The quantity of mash was variable, being all they would eat in half an hour at the close of the day. They ate more in cold weather than in warm, also considerably more when they were laying heavily than when they were yielding few eggs.

The feeding above described was with hens in a house warmed by hot-water pipes, so that the temperature was above the freezing point at all times. The amount of feed required by the birds kept in this house for several years was always less during the winter season than for birds kept in the colder curtain-front houses.

In addition to the 50 to 55 pounds of meal in the mash, the hens in this house have averaged each year 18.2 pounds of wheat, 6.4 pounds of cracked corn, 5.8 pounds of oats, 5.9 pounds of oyster shell, 3.2 pounds of dry poultry bone, 2.9 pounds of mica grit, and 40 pounds of mangolds. The straw for litter has averaged 36 pounds per bird.

CRACKED CORN AND BEEF SCRAP AS A SUBSTITUTE FOR MOIST MASH.

In November, 1903, 300 pullets hatched in April and May were put into 6 pens in the open-front house, and the birds in all pens were selected so as to have the lots equal in quality.

One hundred and fifty of the birds (lot No. 1) were fed on dry grains in the litter during the day, and a full feed of moist mash was given toward evening. The mash was made as above described.

The other 150 birds (lot No. 2) were fed the same quantities and kinds of dry grains in the litter, but instead of moist mash they were given all they would eat of dry cracked corn in troughs at evening. Dry beef scraps were kept within their reach at all times. Both lots were constantly supplied with oyster shell, dry crushed bone, and grit. Mangolds were fed through the winter, and when the runs were bare in summer other green feed was supplied.

The materials used by each lot during the full year averaged per bird as follows:

Lot No. 1, with mash.—Mash, 53.3 pounds; wheat, 23.8 pounds; cracked corn in litter, 7.7 pounds; oats, 6.9 pounds; oyster shell, 8.5 pounds; bone, 4.4 pounds; grit, 4.2 pounds; mangolds, 40 pounds; straw, 36 pounds.

Lot No. 2, without mash.—Cracked corn, 45.4 pounds; wheat, 23.8 pounds; cracked corn in litter, 7.7 pounds; oats, 6.9 pounds; oyster shell, 4.4 pounds; bone, 1.7 pounds; grit, 2.9 pounds; beef scrap, 14.7 pounds; mangolds, 40 pounds; straw, 36 pounds.

Cost of feed and straw: Lot No. 1, $1.73; lot No. 2, $1.69.

Cost of feed without mangolds: Lot No. 1, $1.48; lot No. 2, $1.43.

Eggs yielded: Lot No. 1, 151; lot No. 2, 149.

Comparisons of the costs of the two rations and the egg yields of the birds fed upon them do not show very great advantages of one ration over the other. There were no marked differences in the appearance and health of the birds in the two lots; both were in good general health. The free use of cracked corn cheapened the cost of the ration, and the egg yield was not depressed sufficiently to indicate that this ration was faulty in its production. When compared with the feed required for a hen for one year in the warmed house, which was about 95 pounds, the 109 pounds used in this test is an increase of nearly 15 per cent.

As the birds in each house laid about the same number of eggs, it seems reasonable to suppose that the excess of feed was needed for maintenance in the colder house, where the birds were in outdoor temperature during the daytime throughout the year.

Although as many eggs were yielded by the birds eating less feed in the warmed house, the greater vigor and smaller loss among birds in the open-front house more than compensated for the increased cost of maintenance.

DRY FEEDING.

The comparison of moist mash with cracked corn and beef scrap indicated that the moist mash was not essential to egg production. Beginning the 1st of November, 1903, 550 pullets hatched in April

and May were fed wholly on dry feed. They were in the curtain-front houses, with warm, elevated roosting closets and in flocks of 50, 100, and 150. At 5 o'clock in the morning the flocks of 50 birds were given 2 quarts of cracked corn; at half past 10 o'clock they had 1 quart of wheat and 1 quart of oats. This dry material was all spread on the litter on the floor, but was not raked in. Along one side of the pens were feed troughs with slatted fronts, in which was kept a supply of the dry material of which the moist mash, before described, was composed. These troughs were never allowed to remain empty when the supply was exhausted. The dry mash was constantly within the reach of all birds and they helped themselves at will. Oyster shell, dry cracked bone, grit, and charcoal were accessible at all times. A moderate supply of raw mangolds and plenty of clean water was furnished. When the birds were first put upon this ration they were not acquainted with the dry mixture in the troughs and ate of it sparingly, but in three or four days they were using as much of it as at any time, except when laying heavily. When the feeds of cracked corn, wheat, and oats were given, the birds were always ready and anxious for them, and would scratch in the litter for the very last kernel before going to the troughs, where an abundance of feed was in store. It was very evident that they liked the broken and whole grains better than the mixture of the fine materials, yet they by no means disliked the latter, for they helped themselves to it—a mouthful or two at a time—whenever they seemed to need it, and never went to roost with empty crops, so far as we could discover. They apparently did not like it well enough to gorge themselves with it and sit down, loaf, get overfat, and lay soft-shelled eggs, as is so commonly the case with Plymouth Rocks when they are given warm morning mashes in troughs.

The weights of the feed eaten were accurately kept for the month of March, 1905. During the 31 days of that month the 550 birds consumed on the average the following materials per bird: Cracked corn, 2 pounds; wheat, 1.09 pounds; oats, 0.81 pound; mash, 5.68 pounds; shell, 0.52 pound; bone, 0.25 pound; grit, 0.31 pound; mangolds, 3.30 pounds.

The average egg yield of the birds in flocks of 50 and 100 was 147 eggs for each hen for the year ending October 31, 1905. The dry feeding, as judged by the health of the birds and the egg production, is fully as satisfactory as when the moist mash is used. The dry method has some advantages and apparently no disadvantages. The dry mash is put in the troughs at any convenient time, only guarding against an exhaustion of the supply. There is an entire avoidance of the scrambling and crowding that always occur at trough feeding when that is made a meal of the day, whether it be at morning or evening. There are no tailings to be gathered up or wasted, as is

common when a full meal of mash is given at night, and the labor is much less, a person being able to care for more birds than when the regular evening meal is given.

SIZE OF FLOCKS AND HOUSING SPACE.

The cost of housing poultry is a very important item to the poultryman, and the amount of floor space required by each hen is a question much discussed and worthy of the most careful consideration and investigation. This question is being studied by the Maine Station in cooperation with the Bureau of Animal Industry. While it is still too early to give positive conclusions, an outline of the work under way and some of the results thus far found will have an interest and some value.

The conditions laid down years ago and accepted as imperative that hens could only be kept profitably as layers in flocks of not more than 15, with an allowance of at least 10 square feet of floor space for each bird, required large space for small numbers of birds, and the system was expensive. The small pen, even though containing but few fowls, means close confinement to the occupants. If one hen were confined and compelled to remain on the generous allotment of a square yard, life would be very unsatisfactory to her. But give her 25 square yards of floor room to roam over at will and she will be happy, although she may meet 49 neighbors in her wanderings and divide the room with them; yet the allotment per individual hen is reduced to one-half a square yard.

Each of the pens in house No. 1 has 160 feet of floor space. When occupied by 22 birds each individual has a floor space of 7.3 square feet. Each of the 7 pens in house No. 2 has 240 square feet of floor space, giving each of the 50 pullets 4.8 square feet.

In house No. 3 the four pens are twice as large as those of house No. 2, each containing 480 square feet. In each of two of the pens 100 pullets are kept, having 4.8 square feet of floor space to a bird—just the same allotment that is given in the pens of 50 birds in the No. 2 house. The 150 birds kept in each of the two other pens have only 3.2 square feet to a bird.

Some of the questions upon which it is hoped to get light by these comparisons are: Does the larger room have advantages over the smaller one, when the average floor space to a bird is the same, by giving greater opportunities and freedom to the birds? Are there disadvantages when the number of birds in the flock is increased, the proportioned floor space per bird remaining the same?

Should the tests indicate that the greater liberties of the larger pens are advantageous, the question arises: Are the advantages such that the number of birds in the large pens can be increased and the ratio of egg production be maintained? Also, how far can the net profit

from the pens be increased by increasing the number of birds in each pen, although the average egg yield be diminished by the greater density to which the pens are occupied?

So far as health and egg production are concerned, thus far there is little to choose between the pens containing 22, 50, and 100 birds, with 7.3 and 4.8 square feet to a hen. The fowls in the 150-bird pens, for reasons which are not attributed to the increased numbers or diminished floor space, did not do as well in 1904–5 as those in the other pens.

With pens of the same style and arrangement, and birds matched in age, development, and breed, with the same system of feeding and attendance, and with experiments with large numbers of birds and extending over a number of years, it is hoped to obtain data regarding the sizes of rooms and numbers in flocks which may be of great value to the poultry industry of the country.

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CONTROL AND ERADICATION OF CONTAGIOUS DISEASES.

Inspectors in charge of districts.

Dr. R. A. Ramsay, room 320 Quincy Building, Denver, Colo., in general charge of eradication of scabies of sheep and cattle in the West.
Albuquerque, N. Mex.—Dr. Louis Metsker, room 22 N. T. Armijo Building.
Denver, Colo.—Dr. Lowell Clarke, room 320 Quincy Building.
Fargo, N. Dak.—Dr. R. H. Treacy.
Kansas City, Kans.—Albert Dean, room 328 Live Stock Exchange.
Salt Lake City, Utah.—George S. Hickox, room 21 Eagle Block.

INSPECTION OF LIVE STOCK FOR EXPORT.

Inspectors in charge.

Baltimore, Md.—Dr. H. A. Hedrick, 215 St. Paul street.
New York, N. Y.—Dr. W. H. Rose, 18 Broadway.
Norfolk, Va.—Dr. G. C. Faville, P. O. box 796.
Philadelphia, Pa.—Dr. C. A. Schaufler, 134 South Second street.
Portland, Me.—Dr. F. W. Huntington, U. S. customs office, Grand Trunk R. R. wharf.

INSPECTION AND QUARANTINE OF IMPORTED ANIMALS.

Quarantine stations.

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Halethorp, Md. (for the port of Baltimore).—William H. Wade, superintendent.
Littleton, Mass. (for the port of Boston).—Dr. J. F. Ryder, inspector in charge, 141 Milk street, Boston, Mass.

Inspectors on the Canadian border.

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Carthage, N. Y.—Dr. W. S. Corlis.
Detroit, Mich.—Dr. L. K. Green, care Hammond, Standish & Co.
Fort Fairfield, Me.—Dr. F. M. Perry.
Malone, N. Y.—Dr. H. D. Mayne.
Newport, Vt.—Dr. G. W. Ward.
Ogdensburg, N. Y.—Dr. Charles Cowie.
Orono, Me.—Dr. F. L. Russell.
Port Huron, Mich.—Dr. David Cumming, 912 Lapeer avenue.
St. Albans, Vt.—Dr. C. L. Morin.
Sault Ste. Marie, Mich.—Dr. J. F. Deadman.

Inspectors on the Mexican border.

El Paso, Tex.—Dr. Thomas A. Bray.
San Antonio, Tex.—Dr. Joseph W. Parker.
San Diego, Cal.—Dr. Robert Darling, care Charles S. Hardy.

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Dr. W. H. Wray, 34 Streatham Hill, London, S. W., England, in charge for Great Britain and Ireland.
Dr. T. A. Geddes, care U. S. consulate, Liverpool, England.
Dr. V. A. Nörgaard, Honolulu, Hawaii.

DAIRY INSPECTORS.

M. W. Lang, 423 Marine Building, Chicago, Ill., in charge of renovated butter factories.
Levi Wells, Laceyville, Pa., in charge of renovated butter markets.